JOURNAL

OF

HELMINTHOLOGY

Edited by

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VOL. III., 1925.

Published from the
London School of Hygiene and Tropical Medicine,
23, Endsleigh Gardens,
London,
W.C. 1.

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No. 1 (February, 1925).

No. 2 (May, 1925).

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No. 3–4 (August, 1925).

No. 5 (December, 1925).

Journal of Helminthology, Vol. III., *No.* 1, *February*, 1925, *pp.* 1–14.

Observations on the Life History of *Triodontophorus tenuicollis*, a Nematode Parasite of the Horse.

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Introduction.

The five species of the genus Triodontophorus are parasites of the Equidæ and the Primates ; four of these species are found in the former, and one—*T. deminutus*—is confined to the latter group. Railliet and Henry (1909) created a new genus—Ternidens—for the reception of this single species. Should later work show that this view is tenable, then the members of the genus Triodontophorus will exclusively be parasites of the horse and its allies.

Although a considerable amount of attention has recently been given to the morphology of the different species of this genus (Boulenger, Ihle, Theiler, etc.), the life-histories remain comparatively unknown, the only persons who have observed some of the larval stages being Ihle and van Oordt and le Roux. Ihle and van Oordt (1923) gave some observations, accompanied by some drawings, on some larval parasitic forms, which they suggested might belong to a member of this genus ; le Roux (1924) gave some measurements of larvæ collected by Dr. T. W. M. Cameron, M.R.C.V.S., from a horse in Scotland. With regard to their pathological effects, Ransom and Hadwen (1918) have drawn attention to the fact that *T. tenuicollis* is responsible for causing serious lesions in the colon of the host ; le Roux (1924), has recently confirmed this observation, and the writer can do likewise, as he has never yet obtained this species except in association with ulcerations of the colon.

The material on which this investigation is based was obtained from horses slaughtered in the gardens of the Zoological Society of London. The writer wishes to express his sincere thanks to the Society for the ready way in which it offered facilities to collect material in its slaughter-

house. Over 100 horses were examined, in addition to a few donkeys, of which seven were found to be heavily infected. The material collected by Dr. Cameron was also kindly placed at the writer's disposal.

Methods.

The ulcerated parts of the colon were removed with the worms attached, and were then washed in normal saline. The washings were then carefully examined, and all the nematodes collected in the hope that among them some larval stages might be found. The adult specimens of Triodontophorus were next collected and again washed in normal saline, and the females were separated from the males. From the females the eggs were obtained for making the egg cultures. This was done by first washing them in tap water to remove the saline, and then crushing them in a Petri dish. When this was complete, the crushed material was placed in a sieve of fine mesh and a gentle stream of water played on it, the water passing through being caught in a suitable receptacle. In this way most of the body remnants were separated from the eggs, which passed through the sieve. The excess of water was removed from the eggs either by decantation or by centrifuging. The eggs were then placed in a Petri dish and mixed with a small quantity of moist horse fæces which had previously been heated for half an hour at 65° C. to kill off any nematode eggs present. In order to facilitate egg development, and also to absorb any harmful substances produced, it was found beneficial to mix some animal charcoal with the fæces as advocated by Looss. The Petri dish was then covered and placed in an incubator at 26° C. ; the lid was removed two or three times each day in order to allow free access of air.

Egg cultures were made exclusively from eggs obtained direct from the females, each of which had previously been examined and identified after microscopical examination. In this way it was possible to make absolutely certain that eggs of *T. tenuicollis* only were being used. No attempts were made to collect eggs for culture from fresh horse fæces, because the trouble this would have involved did not appear warranted to the writer ; besides, the fæces generally contain eggs of so many other strongyles that after collection it would not have been possible to definitely say whether the eggs were those of *T. tenuicollis* or not.

Development.

The Egg.—As stated above, the eggs used were obtained exclusively from the adults. *In utero* their contents are found to be in various stages of segmentation from the one-celled to the 16-celled. In some cases even more advanced stages were observed ; none, however, reach the stage at which the beginnings of the embryo can be made out. Segmented eggs from the uterus are elliptical and thin-shelled, and vary in length from 0·098 to 0·105 mm., with a breadth of 0·054 to 0·058 mm. When incubated in shallow water it was found that their development followed the course usual for strongyles. The beginnings of the embryo may in some cases be observed about 15 hours after commencement of incubation, and in most cases the embryo is fully formed and moving inside its shell within 24 hours. Some embryos may now even hatch, but usually hatching does not occur until after about 30 hours. In cultures made up in tap water only most of the eggs had hatched within 40 hours.

Eggs cultured in sterilised horse fæces and charcoal were seen to behave in the same way as those described above. It was only after the first day of hatching that the larvæ behaved differently in the two media ; in the first they became more and more sluggish, and eventually died, before reaching the mature infective stage ; in the latter medium the larvæ grew and remained active, and reached the mature infective stage within four days of the commencement of incubation. If, however, fæces only was used, *i.e.*, no charcoal added, it was noted that after a few days the larvæ became weaker and weaker, and only a few reached the mature infective stage, and that not until the eighth day after incubation. As a rule these larvæ were all dead by the tenth or twelfth day, probably because of the toxic substances produced by the decomposing fæces.

First Stage Larvæ.

The newly hatched larvæ (Fig. 1) are typically rhabditiform, possessing a long slender tail ; they thus closely resemble those of the species of Strongylus and Trichonema. In average length they are about 0·5mm. long, the smallest seen being 0·485 mm. and the largest 0·512 mm. The maximum thickness of the larva is found about midway between the level of the base of the œsophagus and the genital primordium ; here the thickness varies from 0·022 to 0·025 mm. The tail is long and slender, and

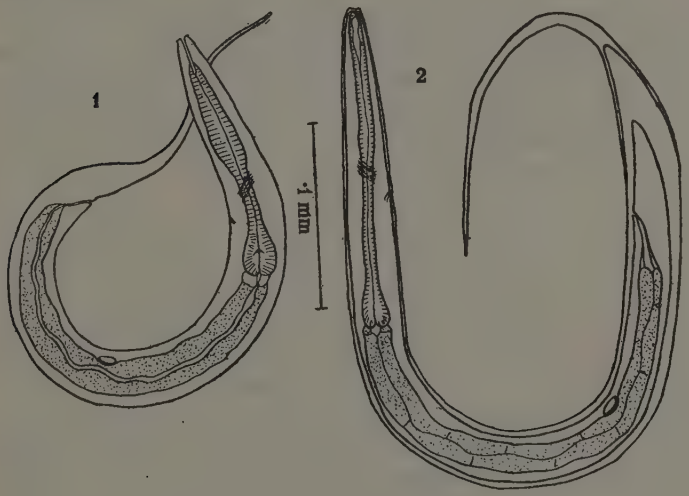
varies in length from 0·13 to 0·14 mm., *i.e.*, it is slightly over a quarter of the total length of the larva. The mouth is terminal and rounded, and is encircled by six refringent spots, which represent the two lateral and the four sub-median head papillæ. The mouth leads into a short cylindrical and cuticularised buccal tube about 0·002 mm. in diameter and 0·015 to 0·016 mm. in depth ; its anterior and posterior margins are slightly thickened so that in optical section it appears as two straight rods thickened at both their ends. The œsophagus, which is rhabditiform, envelops the posterior quarter of the buccal tube, and is itself nearly one-quarter of the total body length. In a 0·488 mm. long larva it was 0·115 mm. long, and the nerve ring encircled it just posterior to its anterior thickening. The posterior œsophageal bulb is 0·016 mm. in diameter, and is provided with the usual three œsophageal valves. The excretory pore is situated opposite the middle of the œsophageal constriction ; it is connected by a thin excretory tube with a unicellular gland lying ventral to the œsophageal bulb. The intestine is a straight tube whose lining cells are densely packed with granules which consequently obscure the limits of the individual cells ; its lumen traverses it in zigzag manner. The posterior end of the intestine is joined to the anus by means of a short cuticularised tube constituting the rectum. An indentation on the ventral side of the intestine, just posterior to the middle of the total length of the larva, serves to lodge the unicellular and lens-shaped genital primordium.

The first stage larvæ continue actively to feed until towards the end of the first day of hatching, when they tend to become quiescent. They are now preparing for their first moult, which may occur from 24 to 30 hours after hatching. This was observed by placing a few first-stage larvæ in a watch glass containing well-aerated water and examining them at short intervals. Although the actual ecdysis was not observed, yet cast sheaths were seen in the water during the periods mentioned above, thus showing that the larvæ had passed into the second stage.

Second-stage Larvæ.

The early second-stage larvæ are morphologically indistinguishable from those of the first stage, and their modes of movement and feeding are also similar. During this stage they feed and increase in length up to maximum, varying from about 0·6 to 0·7 mm. until about the fourth day

after hatching, when a period of lethargy sets in, and the larvæ prepare for their second moult. Towards the end of the fourth day a new cuticle has been formed under the old one, and the old cuticle has become completely separated off from the new one. During this period the larvæ have undergone considerable morphological changes, and so pass into the next stage.



Triodontophorus tenuicollis.

Fig. 1.—First-stage larva.
Fig. 2.—Ensheathed third-stage or infective larva.

Third or Infective Stage Larvæ.

(*a*) *Morphology.*—The third stage larvæ remain ensheathed in their second-stage cuticules. No further growth takes place, neither do they feed. The most marked changes apply to the œsophagus and the tail (Fig. 2). The former has lost its rhabditiform shape, and has become filariform with no cuticular valves in its basal bulb. The latter has become short and conical. The larvæ may completely fill their sheaths, but in most cases a slight contraction of the body takes place so that they can easily move within their sheaths. The length of a fully extended

larva—excluding its sheath—varies from about 0·5 to 0·53 mm., the average being 0·52 mm. with a thickness of 0·024 mm. Its cuticule is more definitely striated than those of its former stages, and the six circumoral papillæ are slightly more prominent. In an average-sized larva the œsophagus was 0·117 mm. long, and the nerve ring was situated at its middle, and the excretory pore posterior to it and 0·135 mm. from the anterior end of the body. Towards its anterior end the lumen of the œsophagus widens out so as to form an elongate and spindle-shaped cavity. The genital primordium has undergone no development, and still occupies a depression on the ventral side of the intestine ; it is situated in the posterior half of the body, about 0·18 mm. from the tip of the tail. The tail, as has already been mentioned, has become considerably shortened, and now forms only slightly more than one-tenth of the total body length.

(*b*) *Biology*.—The third-stage larvæ actively swim and creep about the culture medium. If the sides of the culture dish are allowed to remain moist by, *e.g.*, covering the dish with a glass lid, it will be noted that some of the larvæ will begin to crawl out of the culture medium on to the sides of the dish, and in the condensation moisture on these sides they will wriggle their way upwards and eventually be found on the lid itself. This character of the mature larvæ of *creeping upwards* was made use of in order to collect quantities of clean larvæ, it having previously been found to be a very tedious operation to pick out a sufficient supply of mature larvæ from the black culture medium. This character is perhaps also of considerable importance for bringing about infection of the host. It is known that larvæ of *Hæmonchus contortus* show a similar character of climbing, and in the fields these larvæ climb up moist blades of grass, etc., on which sheep may eventually feed and thus become parasitised. Experiments carried out by the writer with infective larvæ to ascertain whether they can *penetrate skin* have all proved negative. For these experiments the Goodey method was employed, skin of very young rats being used. Although careful search was made in serial sections of the skin on which larvæ had been placed for some hours, both at room temperature, 26° C. and 37° C., yet never was any trace of larvæ found in them. In experiments where a known number of larvæ were used, these could always be recovered again from the surface even after they had been in contact with the skin overnight. Consequently, the conclusion

was arrived at that infection of the host could not be effected by the larvæ penetrating the skin as is the case with the ankylostomes, etc., but that the most probable way would be through the mouth, the host, while grazing, taking in larvæ which had crawled up the grass.

These two characters of climbing and not penetrating skin suggest that the larvæ would be able to withstand variations of *temperature* and *humidity*, as the larvæ, when located on grass or on the surface of the soil after a dewy morning, would, during the day, probably find themselves exposed to a higher temperature and a drier atmosphere. This was actually found to be the case, their capacity for withstanding dessication being very marked; *e.g.*, a known number of larvæ were placed on a glass slide in a drop of water, which was allowed to evaporate off; after half an hour another drop of water was added. The larvæ were now examined, and it was noted that they had shrivelled to a considerable extent, and that their structure was unrecognisable. After a few minutes in the water, however, they began to swell out, and within a quarter of an hour some began to show signs of life, and within an hour all were moving. Some larvæ were also placed in an open watch glass in a drop of water, and the whole placed in an incubator overnight at 26° C.; next morning, on examination, it was found that the larvæ had completely dried up, and that they had shrivelled up beyond recognition. On addition of water it was found that the larvæ revived again within an hour. This method of exposure to dessication is certainly more drastic than would normally be the case in the field, where among the soil particles and grass blades there would generally be a little moisture retained by the soil particles by capillary attraction, or exuded from the grass itself. It therefore appears legitimate to conclude that in the field the larvæ would be even better suited to withstand variations of humidity. With regard to temperature, the larvæ were found to be able to live in temperatures varying from −8° C. to 60° C. Lower temperatures were not tried, and at 60° C. the larvæ were killed. In the lower temperature larvæ were placed in a small tube immersed in a mixture of ice and salt. After a few minutes the water containing the larvæ was frozen hard, and the larvæ were allowed to remain thus frozen overnight by placing them in an ice chest. Next morning, after allowing the ice to melt, it was found that the larvæ very soon began to move, although not at all active; however, after placing them in an incubator at 26° C., they were observed to have

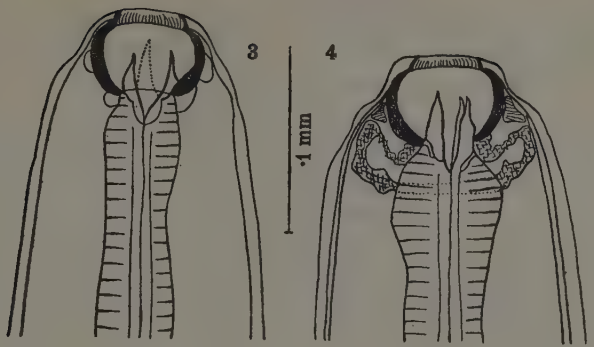
assumed their normal activity within 10 minutes. In order to find the effects of rising temperature, several larvæ were placed on a Leitz heating stage. It was observed that the activity of the larvæ increased up to 32° C., and that their movements appeared regular ; an increase of temperature up to 38° C. was responsible for increased movements, which, however, were of a jerky nature, thus tending to show that this was above their optimum temperature. On further increase of heat the movement became less and less until at 55° C. the larvæ stopped moving and assumed a straightened out attitude as if dead ; addition of cold water to them, however, caused them to revive within a minute. Larvæ which had been exposed to a temperature of 60° C. did not revive after the addition of cold water. Although the larvæ can withstand these variations of temperature, they do not show any inclination to swim towards or from the source of heat, *e.g.*, larvæ placed in a little water towards one end of a slide do not swim towards the middle of the slide which is being warmed by means of a heated glass rod applied to its under surface, neither do they swim away when the rod is placed immediately below them.

Parasitic Stages in Definitive Host.

Among the nematodes collected from the vicinity of the ulcers in the colon, several larval nematodes were found which the writer takes to be the larval forms of *T. tenuicollis*, and which probably represent fourth-stage larvæ. Ihle and van Oordt (1923) described a larva very similar to these ; these, however, being smaller than those obtained by Ihle and van Oordt. The larvæ collected by the writer could be easily divided into males and females, their sexual organs being already clearly indicated, and their tails being quite distinct, being much blunter and shorter in the males than in the females (Figs. 5 and 6).

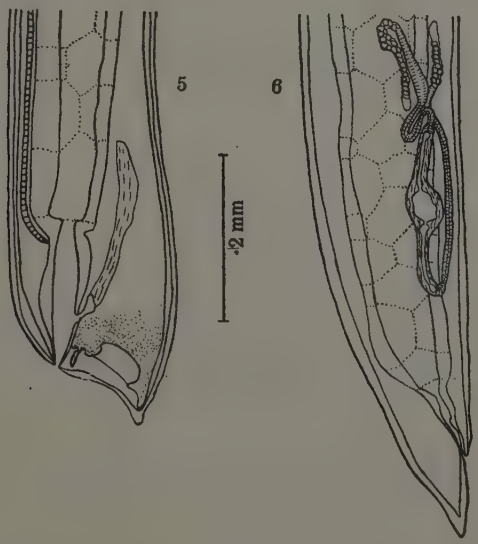
The two sexes differ very little in length, the males varying from 4·23 to 4·86 mm., and the females from 4·61 to 4·94 mm. ; the average thickness of the males is about 0·23 mm., and the females about 0·25 mm.

The mouth in each sex is provided with a distinct mouth collar about 0·007 mm. high, and showing a very delicate vertical striation, probably representing a larval leaf crown. This is followed by a spacious cuticularised buccal capsule much more rounded than that figured by Ihle and van Oordt. It is from 0·038 to 0·04 mm. in depth, and from 0·06 to 0·063 mm. in breadth (Figs. 3 and 4). In the tissue immediately external



Triodontophorus tenuicollis.

Figs. 3 and 4.—Anterior extremities of fourth-stage larvæ, showing buccal capsule, larval leaf crown, œsophageal teeth and beginnings of development of adult buccal capsule.



Triodontophorus tenuicollis.

Fig. 5.—Posterior extremity of fourth-stage male larva.
Fig. 6.—Posterior extremity of fourth-stage female larva.

to the buccal capsule may be seen six strands of fibres, two lateral and four sub-median ; these pass forward and join on to the six-head papillæ lodged in the mouth collar surrounding the mouth.

The buccal capsule rests on the anterior face of the œsophagus, from the three corners of which prominent teeth pass forward into the buccal capsule. There are three of these, one dorsal and two subventral. They are simple and pointed, the dorsal being larger than the other two.

The œsophagus is straight and swells slightly towards its posterior end ; it forms about 1-10th of the total body length. The nerve ring encircles it anteriorly, and divides it into the ratio of 2 : 3. The excretory pore is situated opposite the middle of the œsophagus, and it leads by a short duct into two elongate cervical (excretory) glands extending down some little distance ventral of the œsophagus and intestine. The cervical papillæ are two delicate thorn-like structures situated just posterior of the level of the excretory pore.

The posterior extremity of the male is slightly swollen, and the tail thus appears very short, being only about 0·06 mm. long. In the female the posterior part of the body gradually tapers to terminate in a pointed tail about 0·095 mm. long (Figs. 5 and 6). The measurements given by Ihle and van Oordt for the tails of their larvæ are slightly more than double these figures. In the tails of the males there may be noticed, in different larvæ, early stages in the development of the bursa ; none, however, were so far advanced as to show the different bursal rays.

The genitalia have undergone considerable development : the male organs now consist of a solid rod of cells extending from the posterior end of the intestine to near the middle of the body. Indications of the spicules may also be seen, these being represented by a row of elongate cells commencing about the middle of the rectum and passing dorsal of the intestine. In the female the vagina and ovejectors are already quite distinct ; the former, however, has not yet developed a connection with the exterior. These two structures are already hollow. The representatives of the uteri can also be seen, but these and the ovaries are still solid organs.

The larvæ were taken to represent fourth-stage larvæ because in some of them annular spaces were seen to be present round the base of the buccal capsule. As these were lined by a thick cuticular wall they were

considered to be the beginnings of the adult buccal capsule. That the adult buccal capsule does develop in this way is known from the works of various helminthologists on various Strongyles, *e.g.*, on Ancylostoma, Syngamus, etc.

That the larvæ probably belong to the genus Triodontophorus is supported by the fact that morphologically they possess characters very similar to those of the adults, *e.g.*, spacious buccal capsule and three large œsophageal teeth, these two characters—as Ihle and van Oordt have already pointed out—being found in Triodontophorus only among the adult Strongylids of the horse. The only way of definitely settling this point is either to obtain these larvæ by direct infection experiments or else by finding larvæ in the colon which will show the fully developed adult buccal capsule with the larval buccal capsule still attached. All attempts by the writer to find these larvæ have so far failed, *e.g.*, infective larvæ were on several occasions fed to a monkey on the ground that as it belonged to a group of animals which was parasitised by a closely related species, it might be susceptible to artificial infection with the horse form ; this, however, proved not to be the case, for although it received hundreds of larvæ, no trace of these having set up an infection was ever found by fæcal examination.

It is well known that several Trichonema larvæ encyst in the mucosa of the colon, and consequently it was thought just possible that Triodontophorus larvæ do likewise, and that the larvæ obtained free in the lumen had prematurely escaped. Hundreds of cysts were consequently examined, especially those in horses known to have been parasitised by *T. tenuicollis*, but on no occasion was a larva ever found which could on any ground be considered to belong to the genus Triodontophorus. The writer has consequently come to the conclusion that for its development during its parasitic stages it remains free in the lumen of the gut and never enters the mucosa.

By analogy with what is known as the development of certain other strongyles, the probable course of development in *T. tenuicollis* would then be somewhat as follows : The infective or third-stage larvæ are taken into the digestive tract while the host is feeding ; these larvæ pass into the colon, and may, during their passage to this location, or after their arrival there, cast their sheaths. They would then, after a period of growth,

undergo a third moult, during which period the larval buccal capsule would be formed and differences between the sexes appear. After ecdysis they would represent the fourth-stage larvæ described above. Further development would take place, a new buccal capsule would become formed round the base of the larval buccal capsule, the internal and external sex organs would become better and better differentiated, and when these have all been formed the larvæ would undergo their fourth and last moult and pass into the fifth stage, which represents the young adults. From now onwards simple growth would lead on to the mature adult parasites, which become attached to the wall of the colon and cause the ulcerations associated with their presence.

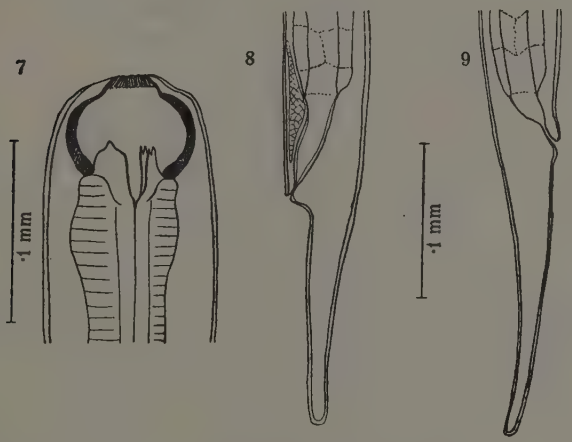
During the course of this investigation the writer was able to examine and compare some material collected by Dr. Cameron in Scotland. The writer here wishes to express his thanks for this privilege.

This material contained several larvæ which the writer takes to be fourth-stage larvæ of some Triodontophorus species. Le Roux (1924) has already given a few data about these, and the writer now takes this opportunity of adding to these.

The larvæ were obtained free in the colon in which adults of *T. brevicauda*, *T. serratus* and *T. tenuicollis* were also present. The writer is of opinion that the larvæ represent a development of one of the two first-mentioned species, as that described for *T. tenuicollis* differs from these in several respects.

About two dozen larvæ were available for study, and as these show the general characters of the larvæ described above, only the salient features will be noted. They are much smaller, being only about 3 mm. long with a thickness of 0·14 mm. The mouth is surrounded by a mouth collar and larval leaf crown, and leads into a somewhat globular buccal cavity about 0·045 mm. deep by 0·058 mm. wide (Fig. 7). The œsophageal funnel is better developed, and its three teeth are comparatively stouter ; they do not terminate in simple pointed tips as in the corresponding larvæ of *T. tenuicollis*, their free ends being somewhat serrated. The relations of the œsophagus, excretory and nervous systems are similar to those of *T. tenuicoliis*. The genitalia, however, are in a much earlier developmental stage, being represented in the male by a solid and somewhat lens-shaped mass of cells on the ventral side of the posterior end of the intes-

tine, and in the female by a rod of cells occupying the same relative position as the male organ and being about 0·15 mm. in length. The posterior extremity of the body in the two sexes are quite distinct (Figs. 8 and 9). In the male there is a sudden thinning of the body immediately posterior of the anus, after which the body tapers very slightly to form a bluntly pointed tail about 0·15 mm. long. In the female the body tapers gradually to form a tail about 0·19 mm. long.



Triodontophorus sp.

Fig. 7.—Anterior extremity of fourth-stage larva, showing larval buccal capsule, œsophageal teeth, etc.

Fig. 8.—Posterior extremity of fourth-stage male larva.

Fig. 9.—Posterior extremity of fourth-stage female larva.

Summary and Conclusions.

1. During the free-living development the larvæ of *Triodontophorus tenuicollis* undergo two moults separating three larval stages, the last stage remaining ensheathed in the cuticule of the previous stage.

2. The development takes about four days when the eggs are cultured in horse fæces and charcoal at 26° C.

3. The infective or third stage larvæ are climbers, and also show a marked resistance to desiccation ; they can also withstand variations in temperature from – 8° C. to 60° C.

4. They do not penetrate skin.

5. Infection of the host is probably via the mouth during grazing.

6. The fourth-stage larva is described. It is free in the lumen of the colon, possesses a well-marked larval buccal capsule and three stout and pointed œsophageal teeth. Sex differences are now present.

7. The adult buccal capsule develops in the form of a vesicle round the base of the larval buccal capsule.

8. The probable mode of its parasitic development is given.

9. A fourth-stage larva, probably that of either *T. brevicauda* or *T. serratus*, is described.

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The Morphology of *Filaria sagitta* v. Linstow, 1907, from the heart of *Tragelaphus sylvaticus* in Nyasaland.

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The specimens here described were contained in cysts from the heart of a Bushbuck (*Tragelaphus sylvaticus*) submitted for examination by A. J. Stent, Esq., of the Vizara Rubber Plantation, Nyasaland Similar lesions have been reported by others from the heart of the Kudu (*Strepsiceros kudu*) in the same region, but no opportunity of examining these has occurred.

The worms appear to correspond to *Filaria sagitta* v. Linstow, 1907, described by v. Linstow from the pericardium of the harnessed antelope (*Tragelaphus scriptus*) in the Kamerun. The examination of these specimens, however, has presented an opportunity for a more detailed description, and certain differences in measurements are noted.

The material comprised two portions of heart muscle containing cysts within the muscle substance ; the smaller cyst, not projecting above the surface, was visible only as an opaque area, it had been previously cut open and contained one female and one male worm ; the larger cyst, however, shewed a projection above the surface the size of a hazel nut, and contained four female and three male worms. The fluid from the cysts was found to contain embryos.

As removed from the cyst, the worms were in a tangled mass intimately coiled together, each worm, on their being separated, retaining its coils in a more or less regular spiral, the tail end of the male being further coiled in a close spiral of three or four turns.

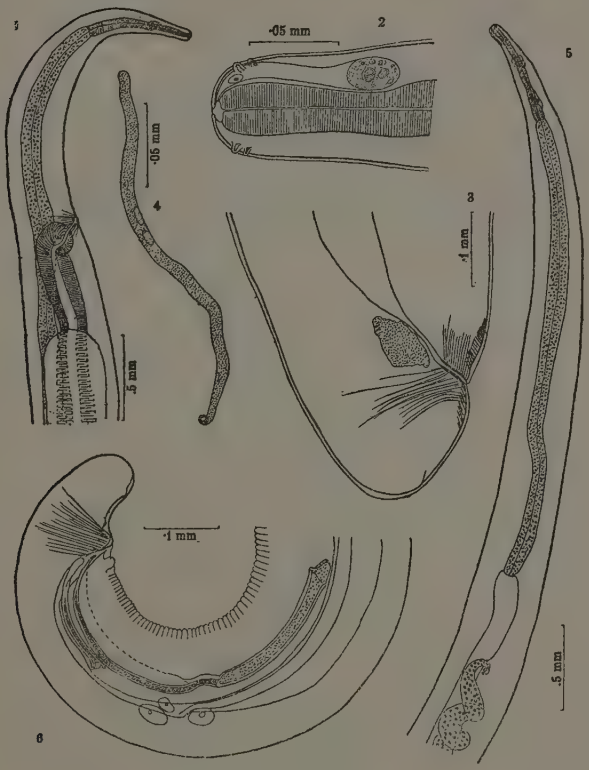
In both sexes the body is moderately thick, and is gradually and evenly tapered towards both ends, which are much thinned. The cuticle is thick and smooth except for some coarse rugæ on the ventral surface of the coiled tail in the male. The mouth is simple, and the rounded head

carries four pairs of very small papillæ, the anterior of each pair being the stouter. (v. Linstow states that there are no papillæ; they are only visible at a high magnification.) A prominent feature is a large dorsal cephalic gland discharging into the mouth cavity by a wide duct, which narrows to a fine point only as it curves round the anterior end of the œsophagus. The œsophagus consists of two portions, a shorter, muscular part, and a wider and longer posterior part extending well beyond the commencement of the genital organs in each sex, as described by Boulenger in the genus *Setaria*, the first part is ·6 mm. long in both, the second 2·675 mm. in the female, 2·3 mm. in the male.

The female is 122 mm. long and ·85 mm. thick, the head being ·0575 mm. broad, and the tail bluntly rounded with a regular even contour, the cuticle slightly thickened at the tip. The vulva, 1·6 mm. from the anterior end (1·97 mm., v. Linst.), opens into a strongly muscular vagina, which passes down the body for a considerable distance overlaid by coils of uterus. Free embryos were observed lying within the lumen; v. Linstow gives measurements of eggs, but without stating whether these were still *in utero* or otherwise; the uterus was full of eggs, the maturer of which were fully embryonated, and as free embryos were seen in the vagina, and found in the fluid from the cysts, it is considered that the worm is viviparous. The anus is ·2 mm. from the tip of the tail, is strongly chitinised, and at its junction with the gut there is a large granular cell lying posteriorly.

The male, smaller than the female, is 85 mm. long and ·7 mm thick, the head being ·055 mm. broad, and the tail tightly coiled in a close spiral. Terminally the contour is evenly rounded, the ano-genital opening is ·115 mm. from the tip, immediately in front of the opening there is a pair of papillæ, and a smaller pair just posterior to it. The spicules, unequal and dissimilar in shape, form a conspicuous feature, the shorter (posterior), ·17 mm. long and ·01 mm. thick, has a somewhat bell-mouthed proximal end, and is bluntly rounded at the tip, the longer, ·55 mm. in length, consists of a stout proximal portion, ·235 mm. long by ·02mm. thick, and a distal part gradually tapering to end in a fine point, this latter portion appears to carry along its concave ventral curve a very transparent membrane, which would account for the flanged appearance on extrusion figured by v. Linstow, who gives the measurements as ·39 mm. and

1·3 mm. respectively. This character of the spicules presents another feature of resemblance to the *Setaria*.



Filaria sagitta.

Fig. 1.—Female; anterior end.
Fig. 2.—Head end.
Fig. 3.—Tail of female.
Fig. 4.—Embryo in blood.
Fig. 5.—Male; anterior end.
Fig. 6.—Male; tail.

The embryos, ·245 mm. long and ·0075 mm. thick are sheathless and of even thickness throughout, except at the tail which is abruptly narrowed and coiled over on itself. Internally they show no definite structure, but are finely granular with faint suggestions of two cell outlines a little anterior to the middle.

These observations were made and are recorded at the suggestion, and under the direction, of Professor Leiper.

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On the Morphology and Systematic Position of *Echinopharynx*, a New Genus of Bursate Nematode from *Testudo tabulata*.

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Our present knowledge of the Strongylid parasites of reptiles is based primarily on Dujardin (1845), who refers all the forms along with those of other vertebrates under a common genus *Strongylus*, and described four species from the reptilian hosts. Since then our knowledge of parasitic fauna has considerably increased, and von Linstow (1878-89) gave an enlarged list under the same genus from reptiles and also a few under the genus *Kalicephalus*. Later, with improved methods of Nematode study the forms described were revised, and it was found necessary to split the genus *Strongylus*, and several groups of a diverse character were recognised. The genus *Strongylus* was thus split up into several genera, and some of them were removed from the family Strongylidæ. The form *Strongylus dispar* of Dujardin from the Anguis fragilis was removed into a separate genus, *Oswaldocruzia* and *Strongylus auricularis*, with its characters in the absence of buccal capsule and the bifid and trifid distal ends of the spicule seemed more closely allied to Trichostrongylidæ Leiper, and was also removed to the genus *Oswaldocruzia*.

Of the remaining forms from the reptiles Diesing (1851) created a genus *Diaphanocephalus* for the reception of *Strongylus galeatus, Strongylus costatus* and *Strongylus viperæ*. Later on a few more species were removed to it. Daubney (1923) described the genus, and gave an account of three new species from the reptiles.

Molin (1861) erected another genus, *Kalicephalus*, and included in it a few species of the genus *Diaphanocephalus* and a few species of the older genera *Strongylus* and *Sclerostomum*. Its separation from *Diaphanocephalus* was commented upon by Baylis and Daubney (1922) as unreliable, and they brought back all forms into the genus *Diaphanocephalus*.

Recently Ortlepp (1923) made a further investigation on these forms, and confirms the conclusion of Molin in his justification for the erection of the genus *Kalicephalus*. Ortlepp (1923) described several new species in the genus.

Both of these genera have a bivalved buccal capsule, and showed close resemblance to each other. Therefore Travassos (1920) placed them into a separate family, Diaphanocephalidæ.

Von Linstow (1908) described a new species, *K. willeyi*, which Baylis and Daubney (1922) brought back into the genus *Diaphanocephalus* as *D. willeyi*. This species, on further investigation by Ortlepp (1923), was found to be of sufficient importance and difference from either of the two genera to justify the creation of a new genus, *Occipitodontus*. Thus the *Strongylid* parasites of reptiles were classed in three genera of a common family.

In addition to the above genera, there still remain a few species whose exact systematic position is doubtful. They are : *Strongylus denudatus*, *Strongylus leptosomus*, and *Strongylus cylindrocephalus*. Their description is so vague that it is not, at the present time, possible to locate them in the correct family. However, with regard to *S. leptosomus* Gervais, we have a brief account and a few figures by Fraipont (1882) that give us an indication for its removal from the family Strongylidæ. It has, in the first place, no bursa, and, secondly, the round anterior end without any buccal capsule and the presence of a large number of small papillæ at the posterior end of the male justify its removal to the genus *Physaloptera*.

The present communication is based on a study of two males and five females, obtained from the intestine of *Testudo tabulata*, differing remarkably from all other genera of Strongyles described so far from the reptilian hosts. It presents certain very interesting features in its anatomy that justify the creation of a new genus, which is named *Echinopharynx*. There is at present only one species which forms the type of the genus and is also given the same name. In the course of my investigation I was struck by an interesting point of asymmetry in the intestinal region of the worm which is described in detail.

I may add here that I am deeply indebted to Professor R. T. Leiper, F.R.S., for the keen interest he has taken in my work. He made valuable

suggestions, and placed the use of his own private library at my disposal. My grateful acknowledgments are also due to Dr. T. Goodey, of the Institute of Agricultural Parasitology, who has given invaluable assistance and encouragement in the course of this work. He has very kindly spent valuable time in examining my preparations, and gave considerable help in the dissection of the worm for the study of the intestinal diverticula.

ECHINOPHARYNX ECHINOPHARYNX. Gen. et sp. nov.

The worms are cylindrically elongated, slightly narrowing towards the extremities. They attain a maximum diameter of ·7 mm. at about the middle of their length.

The females are larger than the males, and measure 8-10 mm. in length, whilst the males are only 7-7·5 mm. long.

The cuticle is thick and shows distinct annulations rather widely apart throughout its extent; each annulus is further marked by very fine transverse striations (Fig. 4). Anteriorly the cuticle is expanded to form the mouth collar, and it supports on its anterior face the circumoral papillæ. The mouth collar is separated posteriorly from the body wall of the trunk by a more or less well-pronounced cephalic groove. The lateral lines are well developed and are composed of large cells.

The circumoral papillæ have the usual disposition—two laterals, two sub-dorsals and two sub-ventrals. The sub-dorsal and the sub-ventral papillæ are composed of two portions. There is a broad basal piece of a cuticular nature resting on the mouth collar, through the centre of which pierces an elongated narrower process terminating anteriorly in a club-shaped structure. The lateral papillæ are blunt, situated a little to the outer side of the sub-median papillæ on the anterior lateral face of the mouth collar. They are connected with the cephalic glands behind. Their structure will be described below.

On the ventral surface of the body behind the œsophagus there is an oval cuticular depression, in the centre of which lies the opening of the excretory organs. The excretory aperture is ·57 mm. from the anterior end of the body.

The cervical papillæ are very narrow and are situated in the lateral position behind the œsophageal region ·57 mm. from the anterior end of

the body. Each consists of a basal portion, through the centre of which pierces a narrow flagelliform outgrowth projecting at the surface.

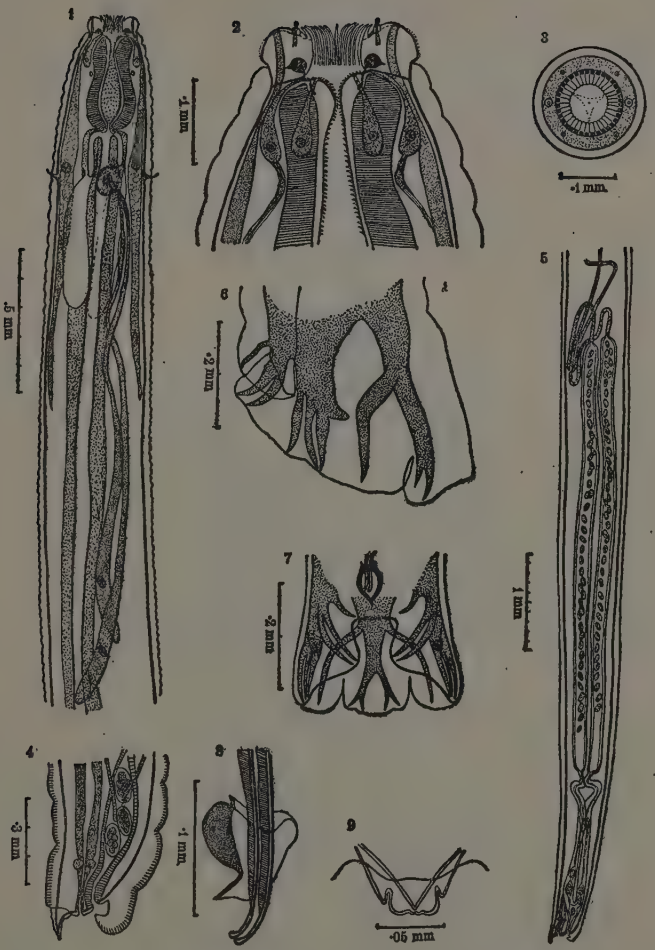
The nerve ring lies ·2 mm. from the anterior end of the body in the constricted part of the œsophagus, and sends off fine processes both anteriorly and posteriorly.

The Cephalic Glands.—There is a pair of these glands present in each worm, beginning anteriorly from the opening of the lateral papillæ. It is rather difficult to study its exact course in the older specimens, where they are easily confused with the enormous development of the sexual organs, but since I was able to find a young specimen I have studied their structure more thoroughly, and give the following account. Leading from the blunt end of the lateral papillæ, each runs as a narrow, faintly granular duct in the cephalic region, and as it enters the body it widens out gradually till it reaches the region of the cervical papillæ, where it is the widest. It then narrows again as it proceeds behind in the body, and imperceptibly merges into the lateral line from which it is very difficult to distinguish here. The glands are full of very fine granules all along, and in their broadest portion each contains a large spherical nucleus 13μ in diameter. From the foregoing description it would appear that the glands and their arrangement resemble the genus *Œsophagostomum* and the reverse of that found in *Ancylostoma*.

The mouth is circular, and leads into a short buccal cavity supported by a thick cuticular ring. This ring of buccal capsule is cut up into 36 distinct segments, and each is produced at its base, both internally and externally, into small outgrowths. Arising from the inner side of the capsule are a series of narrow elongated leaflike processes of a cuticular nature, pointed at their ends. This is the corona radiata and also consists of 36 elements.

Explanation of Figures 1–9.

Fig. 1. Anterior end of a young worm showing general disposition of parts, ventral view.
Fig. 2. Head end, greatly enlarged, showing the œsophageal spines and the organs of problematic nature round the anterior end of the œsophagus. The spines are represented a little larger than the actual size.
Fig. 3. End-on view of the head, showing segmented buccal capsule leaf crowns and circum-oral papillæ. The dotted line represents the outline of the œsophageal cavity.
Fig. 4. Tail end of female, showing marsupium, cuticular striations, etc. Lateral view.
Fig. 5. Posterior end of the adult, showing female genitalia.
Fig. 6. Male bursa, lateral view.
Fig. 7. Bursa, ventral view.
Fig. 8. Ends of spicules and accessory piece, lateral view.
Fig. 9. Genital cone.

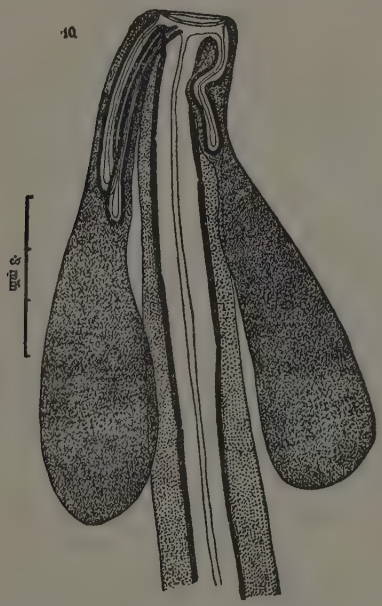


Figs. 1–9. *Echinopharynx echinopharynx* n.g., n.sp.

The œsophagus is dumb-bell-shaped and is narrowest at about its middle, where it is surrounded by the nerve ring. It is ·33-·36 mm. long, and has the maximum diameter of ·18-·22 mm. near its posterior end. There is a wide œsophageal funnel, and the cuticular lining of both the funnel and the œsophagus is very characteristic. It bears a large number of fine spines, looking something like thorns of the rose. They are arranged in several rows all along the œsophageal cavity, and are also found at its opening into the buccal cavity. These spines are so arranged as to hold the food bolus in position, leaving it only when it is being pushed down the œsophagus. This character, viz., the presence of the spines in the œsophagus, gives the name of the genus. The œsophageo-intestinal valves are very small and are turned outwards in the lumen of the intestine.

Intestine.—The intestine is roughly cylindrical, and its lumen is lined with a very thick cuticle. At the anterior end the cuticle of the intestine is evaginated to form three pocket-shaped diverticula that run back along the intestine. This portion of the intestine is very complicated, and the exact relation of the various structures connected with it difficult to understand. This difficulty is further increased owing to the presence of thick refractile nature of the surface cuticle. It was, therefore, found necessary to dissect out the worm and remove the outer cuticle. By a careful dissection under a high-power binocular microscope and mounting this part of the intestine in creosote one can determine the exact relation of these structures to one another and to the intestine by rolling the specimen. It has thus been possible to make out the following structures. The cuticle lining the intestine is segmented in its anterior part and along the inner side of the cuticle runs a layer of very narrow, closely fitting lamellæ that project into the lumen of the intestine, thereby reducing the lumen itself. Its limit is represented by a thin line in Fig. 10. The pocket-shaped diverticula arising out of the intestine are also lined by the cuticle, and there are similar lamellæ too, but both the cuticle and the lamellæ are much narrower and thinner here than in the intestine itself. These diverticula of the intestine are surrounded by the outpushing of the intestinal cells, which form wide ducts round these diverticula, and as they proceed backwards the cells enlarge to form pear-shaped swellings, two in number. It has already been said that there are three diverticula formed

by the cuticular invaginations, yet here we find only two swellings surrounding them. The relation between these structures is hence very peculiar. The cuticular diverticula as they arise from the intestine are so located that one is dorsal and median and the other two are latero-ventral in origin. The cellular swellings are laterally situated. By carefully rolling it is found that the dorsal diverticulum twists round ven-



Echinopharynx echinopharynx n.g., n.sp.

Fig. 10. Anterior part of intestine dissected out to show relation of the intestinal cæca. The fine line inside represents the limit of the lamellæ within the cuticle.

trally to one side, and comes to lie in one of the swellings alongside of the latero-ventral diverticulum of that swelling. Further, it has been found that these organs, which I prefer to call *intestinal cæca*, are very closely applied to the intestinal wall in their anterior part which form the ducts and arise themselves as a pair of outgrowths of the first row of the intes-

tinal cells. They are in reality the two cells of the first row of cells that have greatly enlarged and are pushed out to surround the cuticular diverticula. They run backward along the intestinal cells to which they are very closely applied in the first part of their length, and then enlarge to form the pear-shaped swellings. These cæca are unequal in size, and the larger cæcum contains the dorsal diverticulum in addition to its own lateral one. These cells are full of fine granular materials like the intestinal cells, but the contents differ from the latter in that it is more finely granular in the cæca than in the intestinal cells where the granules are coarse. Probably the contents have become modified in these cæca.

Surrounding the anterior end of the œsophagus, there are three pairs of flask-shaped cells of problematical nature occupying the following position : Two are laterals, two dorsal, and two are ventrals. Each cell is produced anteriorly into an elongated narrow neck that runs forward towards the buccal cavity and is full of very fine granules. They have a comparatively large nucleus situated in the broad end of the cell. The nucleus is spherical and is 40_{μ} in diameter. It was with a certain amount of difficulty that I was able to trace out their termination into the buccal cavity between the œsophagus and the buccal capsule where each duct slightly curves in. Owing to the lack of sufficient material it has not been possible to study the function of these cells, but from their finely granular character it appears that they may be of the nature of glands. Without going further into the details of these organs it may be remarked here that perhaps a study of other genera may reveal the existence of these structures to be universal among the Nematodes.

We have already described the excretory aperture and its position in the body. Here we take the opportunity of describing the glands connected with it. These glands, called the Cervical glands, are two in number, situated ventral to the intestine and going as far back as beginning of the genital glands. In a sexually mature worm they are concealed by the enormous development of the gonads, hence they become rather difficult to study. But in a young specimen it could be thoroughly studied where each gland begins posteriorly in the body as a pear-shaped organ and runs forwards towards the anterior end into a narrow band-like duct to the excretory pore. The ducts of both the glands unite together to form a common duct shortly before entering

the oval rim surrounding the excretory aperture. The glands are full of very fine granules that are more numerous towards the posterior end. Here each gland has an oval nucleus 42μ by 25μ in size. It will be seen that these glands are extremely long and narrow and in a sexually mature individual may, at first sight, be confused with the gonads.

Male Characters.

The bursa of the male is so expanded that the posterior end of the animal does not show any apparent narrowing. It is, however, divisible into three lobes more or less equal in length. Ventrally, the cuticle of the body wall is swollen round the genital orifice to form a well-developed dermal collar.

All the rays of the lateral lobe of the bursa arise by a stout stem common to all. This stem divides into two limbs—a ventral and a dorsal—but before doing so it gives off an elongated narrow ray that is pre-bursal in position. Therefore, the first ray on the ventral side is the ventro-ventral, which arises in common with the latero-ventral ray from the ventral branch of the common stem. The other branch of the stem gives rise to the lateral rays, which consist of three complete rays reaching the edge of the bursa and a small but stout ray representing the extra-lateral ray of *Kilulumа*. This extra-lateral ray is directed upwards at right angles to the others and is about half the length of the other rays of the series. The medio-lateral and the postero-lateral rays are parallel to one another and the externo-lateral ray diverges ventrally. The dorsal ray arises by a separate stout stem from the body wall, gradually narrowing towards the extremity. It gives off, after the first third of its length, a stout externo-dorsal ray on either side and turns back to divide dichotomously twice in its posterior third, thus giving four branches at the end. The externo-dorsal ray at first curves outwards, and then backwards, gradually narrowing to reach the edge of the bursa.

The genital cone is very prominent. Its dorsal lip is conical and ends posteriorly in a point. The ventral lip is, however, irregularly lobed and it bears on either side a small conical lateral papilla, without a

flagelliform process. The dermal collar is, as has been said before, fairly pronounced.

There are two equal and similar spicules attaining a total length of about 4·05 mm. Each spicule is very long and slender, gradually tapering towards its posterior extremity, where it terminates in a rounded knob. All along its length it bears a transversely striated cuticular ala about twice as broad as the thickness of the spicule itself. This ala is absent for a short distance near its tip. The head of the spicule is flanged out.

The accessory piece is very peculiar and appears as a canoe-shaped structure when looked at from the ventral side. It lies in the dorsal wall of the cloaca and is produced both anteriorly and posteriorly into pointed processes. Anteriorly there are two lateral outgrowths, while posteriorly there is only one median process. Laterally, the sides of the accessory piece are prolonged into small triangular outgrowths in the side wall of the cloaca meeting below in the ventral wall, thus forming mast-like expansions, of the canoe.

Female Characters.

The body of the female narrows posteriorly and bears a small conical tail ·12 mm. long in continuation of its dorsal body wall. Ventrally the cuticle is greatly expanded round the genital opening and forms a sort of pouch so that the eggs can be passed out of the vulva into it, where perhaps they can be stored for some time to undergo development.

The anus is ·12 mm. from the tip of the tail and leads into a short rectum ·166 mm. long. It has a thick cuticular lining and its anterior end is marked by the presence of the usual rectal ligament cells.

The vulva is very close to the anus, being ·05 mm. in front of it. As already stated above it is surrounded by a large cuticular expansion forming a marsupium and itself leads internally into a very short vagina ·32 mm. long. The vagina is also lined by cuticle and contains one egg in an advanced stage of development. Anteriorly the vagina divides into two long horns 1·45 mm. long. There is no true ovejector and each horn of the vagina contains a few eggs at various stages of development. Anteriorly the horns are full of eggs and widen out to form remarkably long and straight uteri about half of the total length of the animal.

Each uterus leads into a narrow much coiled ovary of the corresponding side and they both coil round each other till they reach the anterior quarter of the body length. Here they coil back irregularly and form numerous loops.

The eggs are thin walled, elongated and measure ·12 mm. by ·05 mm. As the eggs are passing down the uterus and the horn they begin to segment until we find that in the vagina the egg is in a fairly advanced stage of development.

Discussion on the Systematic Position of the Genus.

The parasitic nematodes of the family Strongylidæ from the reptiles have, as already pointed out, been all put together under Diaphanocephalidæ Travassos. This family is characterised by the possession of a "bivalved buccal capsule and a prominent genital cone." The genus *Echinopharynx* differs remarkably from it in the absence of bivalved capsule, which is here composed of a segmented structure provided with a distinct corona radiata. In this character it resembles the genus *Cylicostomum*. Apart from this it has very little in common with this genus.

The general characters of the genus *Echinopharynx* may be summed up thus:—"Strongylidæ of small size, the mouth opening of which is provided with a corona radiata, the buccal capsule segmented, the œsophagus short and provided with spines; intestine with intestinal diverticula. Prebursal papillæ are long and ray-like, the bursa has a small extra-lateral ray; the dorsal ray divides twice dichotomously in the hinder third of its length, each being thus bi-lobed; spicules two equal and alate, an accessory piece is present. The vulva, surrounded by a shallow marsupium, and vagina is short and divides into two horns; there are no ovejectors." From this it would appear that it could not be classed along with other Strongyles from reptiles under the family Diaphanocephalidæ.

From the characters of the female genitalia it would appear that it resembles in general the genus *Kiluluma*. Both have a vagina with two horns, each leading into the corresponding uterus. Though the short vagina corresponds to the reduced vagina of the Œsophagostomes the absence of the ovejectors in the genus *Echinopharynx* and its

replacement by the long horns indicate it to be a transitional form between *Œsophagostomum* and *Kiluluma*. The comparatively long uteri are, however, different from those found in the genus *Kiluluma* Further the presence of the external marsupium-like structure at the opening of the vulva is quite unique in the group. It is not represented in any other genus of Strongylidæ.

As regards the bursa, we find here again it ranges between the genus *Kiluluma* on the one hand and the genus *Œsophagostomum* on the other. In the genus *Kiluluma* we have an extra-lateral ray in the lateral lobe of the bursa. It is distinctly ray-like in appearance, attaining varying thickness. Here in the genus *Echinopharynx* it is more or less about half the size of the ray and is very stout, so that for all practical purposes it may be regarded as an extra-lateral ray comparable to the extra-lateral of the *Kiluluma*. On an examination of the bursa of the various species of the genus *Œsophagostomum* we can trace the condition of an extra-lateral ray of *Kiluluma*. In *O. dentatum*, *O. asperum*, *O. venulosum* and *O. columbianum* there are only three rays of the lateral series, there being no indication of any rudiment of an extra-lateral ray. In *O. radiatum* and *O. mwanzæ* we find that at the origin of the postero-lateral ray from the main stem there is a pronounced knob at its posterior edge. In *O. eurycephalum* this knob increases in size and in *O. oldi* the knob becomes very distinctly marked out and assumes the appearance of a short rudiment of a ray. Lastly, in *O. simpsoni* it is still larger and is only slightly smaller than the ray in the genus under review. Here in *Echinopharynx* it is distinctly ray-like in character, though short and stumpy. It is further directed at right angle to the other laterals. Thus we can trace the evolution of the extra-lateral ray of the genus *Kiluluma* through the genus *Echinopharynx*. Whether the presence of an extra-lateral ray in *Kiluluma* is a primitive character or an advanced stage in the evolution it is very difficult to decide, but recalling that degeneration is usual in the evolution of parasitic forms I think it more probable that the condition in *Kiluluma* with regard to the presence of an extra-lateral ray is primitive, and in the genus *Œsophagostomum* and other genera with three lateral rays it has degenerated consequent upon the parasitic mode of life, and the genus *Echinopharynx* bridges the gap that exists in the degeneration of the extra-lateral ray of the series. Thus, in the presence of the extra-

lateral ray and the alate spicules in the male and the presence of long horns of the vagina and the absence of the ovejectors in the female the genus indicates its affinities with the genus *Kiluluma*. These, in my opinion, are sufficient characters for putting the genus *Echinopharynx* in the sub-family Kiluluminæ, Thapar (1924).

There are, however, other characters like the presence of spines in the œsophagus, intestinal cæca and the marsupium at the posterior extremity of the female round the vulva, which are diagnostic enough to distinguish the present genus from *Kiluluma*.

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The Cestode Genus *Mesocestoides* Vaillant.

By

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INTRODUCTION.

THE genus Mesocestoides was created in 1863 by Vaillant to receive a new species of cestode found by him in *Viverra genetta* and named *M. ambiguus*. Unfortunately, the description of this form is such that, although the generic characters can be recognised, it is impossible to say to which of the several species found in mammals it should be referred, and therefore Fuhrmann (1908) regarded it as a *species inquirenda*. Weiss (1910), in redescribing a form of Mesocestoides from the same host, gives no details which would enable the parasite to be distinguished from the other members of the genus. He notes that his form is only 50 mm. long, while that described by Vaillant was 160 to 240 mm. long. However, as Neumann (1896) points out, *M. lineatus* has a size varying between 30 and 250 mm. The size of *M. ambiguus* therefore is only of use in showing that it does not belong to the species *M. bassarisci* or *M. cæstus* referred to later in this paper. It still leaves its identity a matter of speculation as, in addition to *M. lineatus*, *M. mesorchis* has dimensions which fall within these limits.

Although it is not possible to identify with certainty the type of the genus, it is obvious that *M. ambiguus* and the forms subsequently referred to this genus are generically related, and the generic characters may be summarised from our knowledge of these other forms.

Mesocestoides is especially characterised by an *apparent* combination of Pseudophyllid and Cyclophyllid features. The scolex has four suckers, while the genital opening is ventral in position. This combination is, however, only apparent. The internal organisation is typically Cyclophyllid, but the organs have been turned through a right angle. The

male and female apertures open at a common genital cloaca, and not at separate points as shown by the older writers. There is no uterine pore (although one is shown in Zschokke's figures of *M. litteratus* and *M. lineatus*), and the eggs are typically Tænioid in character. An interesting character in this genus is the presence of two yolk glands situated in the posterior part of the segment close to the ovary. The most peculiar character, apart from the situation of the genitalia, is the secondary formation of a single egg-capsule (containing *all* the eggs) within the posterior part of the uterus, and the atrophy of the anterior portion. The egg-capsule lies close to the posterior transverse excretory commissure, and so can easily reach the exterior. Its future history, however, is unknown.

Meggitt considers that the Cyclophyllidea possess a single yolk-gland in each segment. The genus Mesocestoides has two such glands, which, however, lie in the same situation as the single gland of the other forms. In its general organisation the genus is so obviously Cyclophyllidian that it would seem that Meggitt's definition should be altered. This genus is the only member of the sub-family Mesocestoidinæ of the family Mesocestoididæ. It occurs in mammals and birds.

In the present paper two new species of Mesocestoides are described, one from the Thibetan fox and the other from the Cape ratel ; *M. lineatus* is also re-examined. In the description the term " mature " segment is to be understood as a proglottis in which both male and female glands are active ; while the term " gravid " refers to segments in which the eggs are completely formed. The word " ripe " is ambiguous and should not be used.

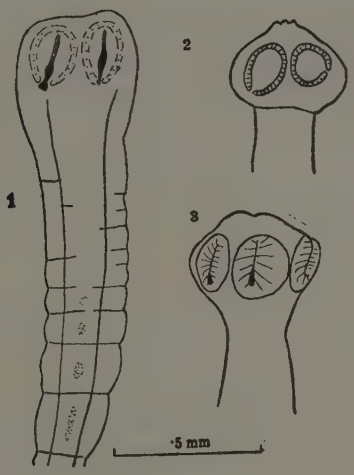
Mesocestoides mesorchis sp. nov.

The specimens of this species were obtained from the small intestine of a Thibetan fox (*Vulpes ferritatus*), which died in the Zoological Gardens, London, six months after its introduction direct from Nepal.

The parasites were obtained alive and fixed in picro-acetic or in Schaudinn's solutions. Unfortunately, the cestodes were very brittle, and only a few entire specimens were obtained. Numerous fragments were, however, recovered. The complete worm is about 75 mm. long in an extended condition, with a maximum breadth of about 1 mm. It, at first sight,

shows some superficial resemblance to a small Dipylidium. The gravid segments especially have a cucumber-seed outline ; the mature segments are also elongated, but have a more rectangular appearance. Only the immature segments are broader than long. The segments never have a serrated border as in the case of the next species.

The *scolex* (Figs. 1-4) is about ·5 mm. in diameter. It is a very muscular structure, with no trace of either rostellum or hooks. The cuticular



Mesocestoides mesorchis n.sp.

Fig. 1. Scolex. Fig. 2. Scolex showing gap in muscular wall of suckers.
Fig. 3. Scolex showing orifices of suckers.

lining of the suckers, however, is roughened with innumerable minute irregular projections, which are only visible under the oil-immersion objective. There are four suckers, two ventral and two dorsal. The members of each pair are separated by a longitudinal non-muscular groove, which appears to be constant in spite of the muscular nature of the scolex (Fig. 4). The suckers are large (about ·2 mm. in diameter) and very muscular, and are embedded in the substance of the head with normally a slit-like opening to the exterior. The musculature of the suckers is not complete posteriorly.

The *neck* is very short, and the strobile becomes segmented about 1 mm. behind the scolex. Traces of the genital primordia are seen after the first few segments.

The *musculature* of each proglottis is not highly developed, and consists of a thickish outer layer of longitudinal fibres, inside of which is a thin layer of transverse muscles (Fig. 10).

The *excretory system* consists of four longitudinal vessels arranged laterally to each other. The outer pair is small and inconspicuous even in the earlier segments, and disappears altogether in the fully mature proglottis. The inner pair rapidly increases in size and, in the mature and gravid proglottides, is large and conspicuous. They are united at the junction of each proglottis by large transverse commissures.

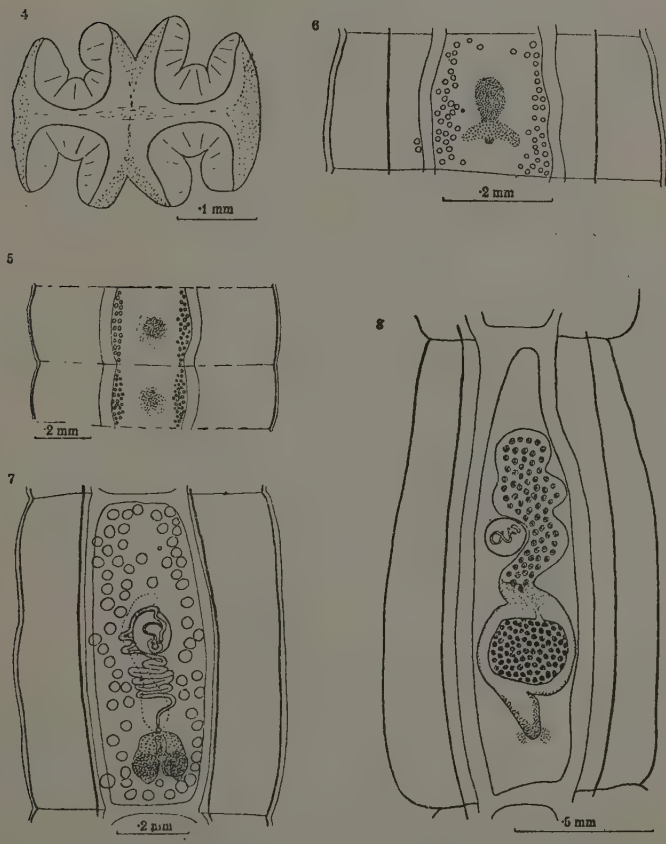
The longitudinal *nerves* lie between the inner and outer vessels.

Numerous calcareous corpuscles are present, and unless the parasite is fixed in an acid medium, they almost obscure the genitalia in stained segments.

The *genital aperture* is almost median in position, and lies just anterior to and slightly laterally of the central point of the ventral surface (Figs. 7 and 10). The genital opening consists of a short dorsally directed canal, which opens into a flat discoid atrium. From the central point of the disc passes the male canal, while on the anterior margin is situated the opening of the female duct. There are not separate male and female genital openings on the surface of the proglottis. It is difficult to determine this without the aid of serial sections or dissections: the latter proved very useful. A stained mature segment was isolated on a slide, and with a sharp scalpel was cut parallel to the longitudinal canals into approximately three equal portions. The central part, containing all the genitalia, was placed on one of its cut edges and studied laterally on a slide. By this means the topography was easy to follow (Fig. 10). The dorsal and ventral faces of such a dissection are easily pulled apart by needles, and the vagina can be thus unravelled.

The *male* opening communicates with an almost spherical cirrus-sac about ·15 mm. in diameter. The cirrus is sufficiently long when extruded to reach to the edge of the segment. It is a thick-walled, structureless tube with a pyriform base.

There are about 50 testes in each proglottis. They are confined to the space between the large longitudinal canals, and in the posterior and



Mesocestoides mesorchis n.sp.

Fig. 4. Scolex; transverse section.
Figs. 5–6. Immature segments.
Fig. 7. Mature segment.
Fig. 8. Gravid segment.

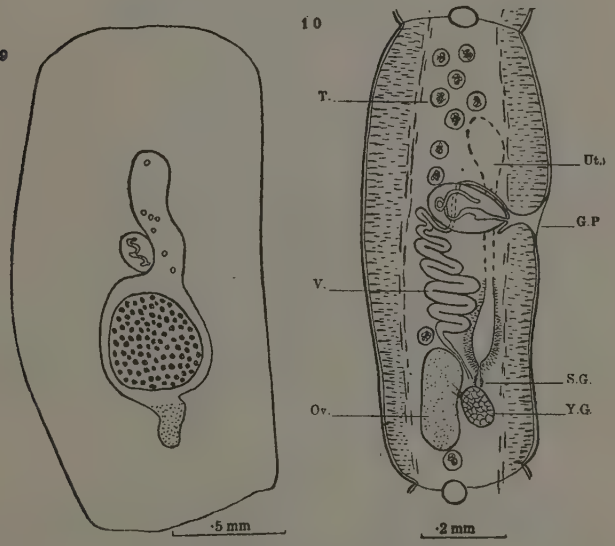
anterior regions of the segment they cross the middle line. Two or three dorso-ventral rows are present. Each testis consists of a granular mass enclosed in a spherical hyaline capsule about ·3 mm. in diameter. Testes commence about the fifteenth segment, and are still visible in young gravid segments.

The *female* glands are functional from about the fiftieth segment, and are active for the next 25 proglottides. The ovary is a double body (as in the genus Tænia), connected by a median commissure. It is situated in the posterior region of the segment and lies dorsal to the yolk glands (Figs. 7 and 10). The shape of the organ and the position of the connecting commissure are very variable. It is typically kidney-shaped, but not infrequently it has a very irregular outline. Although a very compact gland, it has no limiting membrane like the testes. The yolk glands consist of two spherical structures (about ·08 mm. in diameter) lying about the same level as the ovary. They are connected by a short median duct from which springs a common yolk duct to join the oviduct. The position of the yolk glands is also subject to some variation, but they normally lie about the centre of the ovary. A small shell gland surrounds the oviduct close to the point where it joins the uterus.

The *vagina* is a very long convoluted tubule arising at the anterior margin of the discoid genital atrium (Fig. 10). It has no sphincter and passes as a narrow tube along the top of the cirrus-sac until about its equator, when it runs posteriorly on one side (usually the same side as the uterus). Behind the uterus it becomes very convoluted, and when straightened out is found to be about three times the length of the segment. It joins the oviduct as a very narrow tube.

The *uterus* is present at a very early stage, but only becomes functional about the seventy-fifth segment. It consists of a thin-walled wide tube, which originates at the level of the anterior margin of the ovary (Fig. 10), and passes laterally to the central vagina and cirrus, to the anterior region of the segment, where it ends blindly. The posterior third of the young uterus in the mature segment is surrounded by a mass of deeply staining cells, which increase rapidly in numbers and form a large elongated body inside of which lies the hind part of the uterus, now narrowed to little more than a tube which bifurcates at the posterior end. This bifurcation rapidly enlarges and becomes spherical, while the deeply staining mass,

which appears to be of a glandular nature, decreases in thickness. The anterior part of the uterus embedded in this gland remains as a narrow tube until the segment is completely gravid. The free portion of the uterus meanwhile has increased in size, although retaining its elongated shape, and the eggs pass through the glandular portion of the uterus and collect in it. The connection between uterus and genital glands



Mesocestoides mesorchis n.sp.

Fig. 9. Segment migrating in fæces.
Fig. 10. Sagittal section showing female genitalia.

finally atrophies, and at this stage the eggs pass back into the spherical cavity referred to above. Finally, practically all the eggs are within it, a fibrous covering is formed, and a single egg capsule, containing all the eggs but with no matrix, comes to lie free in the cavity (Fig. 7). At this stage the segment becomes detached (Fig. 8) and is found free in the intestine and fæces. There is no uterine pore.

The *ova* are typical tænioid in appearance, with the usual six hexacanth hooklets and a single shell.

This species differs from those hitherto described from mammals by the absence of testes from the regions lateral to the large longitudinal canals and their presence in the middle line, and by the very short neck. Accordingly the name *Mesocestoides mesorchis* is proposed for this form.

MESOCESTOIDES BASSARISCI MacCallum, 1921.

This very small form is only 4 mm. long, and appears to occupy much the same position with regard to the other members of the genus as does the adult Echinococcus to the other species of Tænia. It has been reported only from *Bassaricus astuta*, a coyote found in Southern North America. It resembles *Mesocestoides mesorchis* in the location of the testes within the space bounded by the lateral canals; but it differs from it in other important characters. The neck is smooth and unstriated for about one-quarter of the entire length of the worm. The mature segments are indistinctly divided from each other, and the testes are comparatively large and few in number. There are only a very few mature and gravid segments. These points, together with the small size and geographical distribution of the parasite, seem to leave no doubt as to this being a distinct species. Unfortunately, owing to its inadequate description, it is not possible to determine more exactly its relationship with the other species.

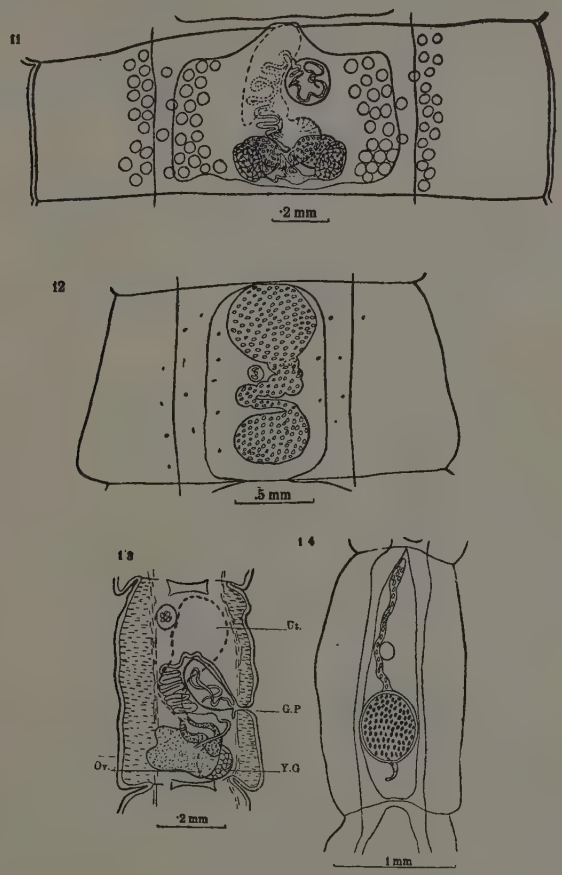
MESOCESTOIDES CÆSTUS sp. nov.

The specimens of this species were obtained from the small intestine of a Cape ratel (*Mellivora ratel*) from N.E. Africa, which died in the London Zoological Gardens six days after admission.

The specimens were obtained alive and fixed in picro-acetic and Schaudinn's solutions.

This is the largest species of Mesocestoides yet described, attaining a length of over 80 cm. and a breadth of 2 mm. at its widest part. Only the gravid segments have a cucumber seed-like appearance. The earlier segments are broader than long, and as the anterior margin of each is slightly shorter than the posterior margin, a gently serrated appearance is given to the entire strobile, excepting the few gravid segments which are elongated and curved.

The *scolex* is about ·5 mm. long and ·45 mm. in diameter. It is similar in appearance to the previous species. The neck is much longer in this



Mesocestoides cestus n.sp.

Fig. 11. Mature segment. Fig. 12. Semigravid segment.
Fig. 13. Sagittal section through mature segment.
Fig. 14. Gravid segment.

species than in *M. mesorchis*, and the first traces of the genital primordia appear about 3·5 mm. from the scolex, although segmentation does not commence until about 12 mm. from the head.

The *musculature* is similar to the previous species, but is rather better developed (Fig. 13). The excretory system consists of the same four laterally arranged elements. The inner tubes are very wide, while the outer are very small and quickly disappear. The transverse commissures are also very large and conspicuous (Figs. 12 and 13). The diameter is greatest where it leaves the lateral tubes and decreases in the centre of the proglottis.

The *genital pore* lies at the junction of the middle and anterior thirds close to the central ventral line. It has a similar discoid atrium to that of *M. mesorchis*, but in this case the female opening is slightly lateral to the middle point of the anterior margin. The cirrus sac is large, elongated and directed in an antero-dorsal direction. The cirrus is very long and thick, and is practically always extruded in the mature segments. Its total length when extruded is about ·12 mm.

There are about 60 large *testes* (·05 mm. in diameter) which lie for about an equal distance on both sides of the large longitudinal vessels in three or four dorso-ventral layers. They never invade the central field as do those of the previous species.

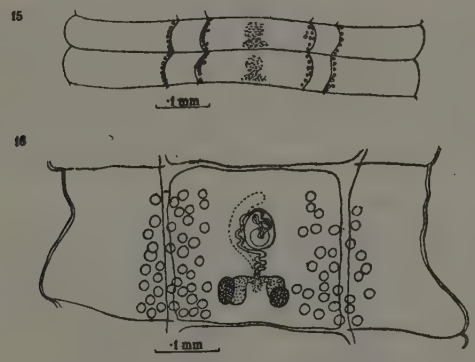
The *female* glands are similar to those of *M. mesorchis*, but are more constant in shape. The ovary lies dorsal to the yolk and shell glands, and consists of two spherical elements with a thin connecting commissure. The shell gland is small and inconspicuous. The *vagina* is very large and even more convoluted than in the first species.

Traces of the *uterus* are found in the immature segments in this form, and in the mature proglottides it appears as a wide, thin-walled tube passing from the level of the ovary to the anterior extremity of the segment. It is remarkable for its size and voluminous appearance. The glandular cell mass is also present at an early stage in the growth of the uterus, but it is only in the later proglottides that it develops into an egg-capsule. The uterus in the semi-gravid segments—of which there are a very large number—becomes dumb-bell-shaped (Fig. 14) with a large anterior globular swelling, in addition to the growing egg-capsule. This gives a very characteristic appearance to this species. The anterior swelling gradually disappears and only the egg-capsule remains in the gravid segments.

The *ova* are typical with a diameter of ·02 mm.

This species is characterised by its very great length ; the serrated edges of the non-gravid segments (which are broader than long), and the cucumber-seed appearance of the gravid segments (which are longer than broad) ; the large transverse excretory commissures ; and the dumb-bell shape of the semi-gravid uterus.

It is so unlike any other form that there is no doubt that it is a separate species, and the name *Mesocestoides cæstus* is proposed for it.



Mesocestoides lineatus.

Fig. 15. Immature segment. Fig. 16. Mature segment.

MESOCESTOIDES LINEATUS (Goeze, 1782).

This species was discovered in dogs by Goeze in 1782, and has been frequently reported since from various carnivores. It was re-described by Zschokke in 1888, and some additional details were added by Neumann in 1896. Zschokke at the same time described *M. litteratus* from the fox and drew attention to the differences between the two forms. These differences—slightly different shape of scolex and minor irregularities in the genitalia—do not seem to be adequate according to modern ideas, and most helminthologists believe that both belong to the same species. Another species, *M. angustatus*, has been described from the badger (*Meles meles*), which Krabbe considered was identical with *M. lineatus* ; and this point has never been cleared up.

The writer has had the opportunity of studying specimens from two badgers and a fox (all from Britain) which had previously been examined by Vevers (1922). He agrees with Vevers that all these forms belong to the species *lineatus*. They agree with Zschokke's description except that the male and female glands have a common opening, whereas both Zschokke and Neumann stated that, although the openings were close to each other, they were separate. In the present specimens also the testes (Fig. 16) have a slightly different disposition from that figured by Neumann. In his figure, they are scattered irregularly over the proglottis, while in the present specimens they are confined to the area surrounding the large longitudinal excretory ducts. There is reason to believe, however, that Neumann's figure is slightly diagrammatic.

This species is similar in appearance to that described above from the Thibetan fox, but may easily be distinguished from it by means of the two *double* rows of testes in the immature segments (Fig. 15). In *M. mesorchis* two *single* rows only are seen (Fig. 5).

The occurrence of *M. lineatus* in the badger does not preclude the possibility that *M. angustatus* is also a valid species. This point can only be settled by an examination of Rudolphi's types. Until this is done, *M. angustatus* must be accepted as a *species inquerenda*, while *M. lineatus* can be regarded as a definite parasite of this host.

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Œsophagostomum longicaudum n. sp. from the Pig in New Guinea.

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Introduction.

In a varied collection of parasitic worms sent by Dr. G. M. Heydon, of Raboul, New Guinea, to Prof. R. T. Leiper, Director of this Institute, there were a number of specimens of *Œsophagostomum dentatum* which had been taken from the large intestine of a pig. An accompanying letter stated that the pigs at Roboul are crossbred between the local wild pig and European breeds.

Prof. Leiper handed the worms to the writer for identification, and during the examination of the material a few were found with very long tails. These at once attracted attention, and a careful search was made for more which resulted in the discovery of six long-tailed females. Examination of these showed that they possessed one marked difference from the normal *O. dentatum* in that the commencement of the œsophagus was distinctly swollen. Making use of this character, a careful examination of all the male worms was made, which revealed the presence of two specimens having an œsophagus with the enlarged anterior end. In all there were 106 normal worms and 8 of the new species in the material. After clearing and mounting the worms in lactophenol a study was made of them which has resulted in the discovery of a number of points of difference from the normal *O. dentatum* sufficient to warrant the creation of a new species for which the name *longicaudum* is proposed.

Œsophagostomum longicaudum n. sp.

All the specimens of *O. dentatum* and of the new species were young adults, not quite fully grown or sexually mature, as shown by their size and absence of eggs from the uteri and oviducts. The measurements, therefore, which are given in the following account are probably on the small side, and if other observers find this new species it is quite probable

that their measurements may exceed certain of those given here, particularly if they examine sexually mature specimens.

The cuticle is distinctly annulated posterior to the cervical groove and bears fine striations.

The *mouth collar* is inflated as in *O. dentatum*, and is limited behind by a well-marked *cephalic groove*. It carries the *circumoral papillæ*, which have the usual disposition. The cuticle between the cephalic groove in front and the cervical groove behind is inflated to form the *cephalic vesicle*. This region of the body has the appearance of a short, truncate cone, and is somewhat shorter and stouter than the corresponding region in *O. dentatum* (*c.f.* Goodey, 1924, Figs. 1 and 2), due, no doubt, to the swollen character of the anterior end of the œsophagus. The *cervical papillæ* have the same structure and a corresponding situation to those of *O. dentatum*.

The *excretory pore* opens into the cervical groove in the mid-ventral line.

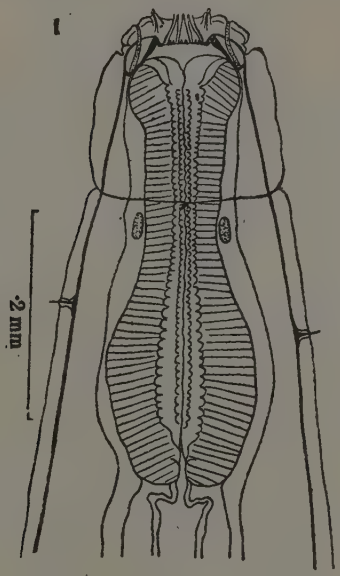
Cephalic, *cervical* and *œsophageal glands* are the same as in *O. dentatum* and call for no special comment. The *nerve ring* is situated a short distance behind the level of the cervical groove. The mouth opening is in the centre of the mouth collar, and is surrounded by an *external leaf crown* composed of nine elements, each of which has two small elements of the *internal leaf crown* at its base exactly as in *O. dentatum*. The buccal capsule is in the form of a ring of cuticular substance. In optical section it can be seen that its sides are not parallel as in *O. dentatum*, but that they diverge posteriorly and at the same time decrease in thickness as they approach the anterior face of the œsophagus. As already mentioned, the commencement of the œsophagus has swollen sides, and is almost globular in outline, whereas in *O. dentatum* the sides of the corresponding region are practically parallel. After this swollen region the sides of the œsophagus narrow down and run almost parallel to each other for some distance, and then begin to swell out again in the posterior region. The whole structure may be described as vase-shaped and not club-shaped as in *O. dentatum*. It varies in length from ·38-·42 mm.

The œsophageo-intestinal valves are as in *O. dentatum* and call for no special comment.

There is a short œsophageal funnel, and the cuticular lining of the œsophagus has its outer margins rounded into numerous knobs as in *O. dentatum*, which serve for the attachments of the œsophageal muscles.

Male Characters.

The special male organs, bursa, genital cone, spicules, gubernaculum and telamon, are similar in all respects to those of *O. dentatum*, and call for no



Œsophagostomum longicaudum n. sp.
Fig. 1.—Anterior end in ventral view.

special description. The only differences which could be found on comparing the two males of *O. longicaudum* with those of *O. dentatum* were that the spicules are shorter in *O. longicaudum* than in *O. dentatum*, and the proportion of handle to the blade in the shovel-shaped gubernaculum is less in *O. longicaudum* than in *O. dentatum*. The spicules in the two specimens of *O. longicaudum* measured ·91-·95 mm., whereas the spicule length in *O. dentatum* varies from 1·15-1·3 mm. In small, sexually immature males

of *O. dentatum* taken from those amongst which the new species occurred the spicules in all cases measured more than 1·1 mm. in length, so that the shorter length of the structures in *O longicaudum* may safely be taken as a specific difference of diagnostic value.

In the case of the gubernaculum, the handle portion in *O. longicaudum* is shorter than in *O. dentatum*, and is in proportion to the blade approximately as in 1 : 2, whereas in *O. dentatum* the proportion is nearer as 1 : 1. The general size, shape and appearance of this structure are the same in both species.

Female Characters.

The posterior end of the female begins to narrow down a short distance anterior to the vulva, and thence it gradually tapers to a long sharp point. The distance from the tip of the tail to the anus is from ·46-·4 mm., which is much greater than the corresponding length distance in *O. dentatum*, where it measures about ·35 mm. in sexually mature forms. A greater distance also separates the anus from the vulva in *O. longicaudum* than in *O. dentatum*. In the former it varies from ·38-·46 mm., whereas in the latter it is from ·36-·38 mm. These two regions give the tail its characteristic long appearance, which is very marked when seen side by side with females of *O. dentatum*. The *rectum* is about ·25 mm. in length and has the usual cuticular lining. The *vulva* is slightly protuberant and leads into the vagina, which, in five out of the six worms, is directed inwards with a distinct posterior curve in the middle of its course, as shown in Fig. 2, whilst in the sixth specimen it is directed forwards and inwards exactly as in *O. dentatum*. Judging from the few specimens available, the course figured is the normal one in the species, though the same direction as that found in typical females of *O. dentatum* may also occur. At its inner end the vagina connects with *pars ejectrix* of the ovejector apparatus, which is normal in structure and requires no special description. The course and direction of the vagina within the body is, no doubt, determined by the relative position of the ovejector apparatus. If this reaches practically to the level of the vulva, the vagina will be pushed in the direction shown in Fig. 2, where the outlet from the centre of the pars ejectrix is only very slightly in advance of the vulva. If, however, the ovejector apparatus does not extend as far posteriorly as the vulva the vagina will have the forwardly directed course normally found in *O. dentatum* and in one specimen of *O. longicaudum*.

The rest of the female genitalia is normal and calls for no further description.

Œsophagostomum longicaudum n. s.p.

Fig. 2.—Posterior end of female in lateral view.

Briefly summarised, *O. longicaudum* may be differentiated from *O. dentatum* on the following points :—

1. *General Characters.*—Broader head, giving the cephalic vesicle the appearance of truncate cone ; different shape of buccal capsule in optical section, sides not parallel, but capsule ring thickest in front and thinning posteriorly.

Œsophagus swollen at anterior end, vase-shaped rather than club-shaped.

2. *Male Characters.*—Spicules considerably shorter than in *O. dentatum* and handle portion of gubernaculum less than half the total length of the structure.

3. *Female Characters.*—Tail very long and tapering, anus and tip of tail farther apart than in *O. dentatum*, also greater distance separating anus and vulva than in *O. dentatum.*

Vagina may be directed almost horizontally with a posterior curve in its course or it may be the same as in *O. dentatum, e.g.*, inwards and forward.

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Journal of Helminthology, Vol. III., *No.* 2, *May*, 1925. *pp.* 51-62.

Observations on certain Conditions Requisite for Skin Penetration by the Infective Larvæ of Strongyloides and Ankylostomes.

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Introduction.

Our knowledge that the infective larvæ of certain parasitic nematodes are capable of actively boring into intact skin and of thus gaining entry into the host dates from the epoch-making discovery of Looss, who, in 1897, accidentally infected himself with *Ancylostoma duodenale*, the mature larvæ of which entered through the skin of his hand (Looss, 1911, pp. 456-459).

He was quick to realise that he had chanced upon a natural phenomenon of first-rate biological importance, and though his first experiments and the results of his subsequent investigations met with a large amount of adverse criticism, much of it ill-informed and misdirected, he finally proved the complete accuracy of his observations.

About four years after Looss' first paper announcing the discovery of skin penetration, published in 1898, Van Durme (1902) discovered that the infective filariform larvæ of *Strongyloides stercoralis*, obtained in cultures of fæces from a chimpanzee, could penetrate intact guinea-pig skin.

Following these original discoveries, many workers studied the infectivity of Ankylostome and Strongyloides larvæ. The method of investigation generally employed consisted in the application of the larvæ to the skin of a live animal and the subsequent finding of them in sections of excised portions of the skin and other deeper-lying tissues. The behaviour of the larvæ on the skin and the actual process of skin penetration have not received much attention at the hands of investigators until recently, chiefly owing, no doubt, to the lack of suitable methods of observation. A knowledge of the physical conditions requisite for pene-

tration is, however, of great scientific interest, as it is so intimately connected with the biological relationship of the parasite to the host. It is, moreover, of great practical importance also in view of the light it throws on the possibility of the host becoming infected in the normal course of its existence.

Historical.

Looss' original accidental infection took place as the drop of water containing the larvæ lying on the surface of the soft skin between the bases of the fingers dried up, and the burning sensation caused by the penetrating larvæ was only felt when the drop had nearly disappeared. (Looss, 1911, p. 458.) In most of his later investigations the experiments were so conducted that either the drops containing the infective larvæ were allowed to dry in the air or the liquid containing the larvæ was placed on the surface of a layer of sacking applied to the skin of the experimental animal. In the latter case it was necessary for the larvæ to make their way through the interstices of the sacking before they arrived at the skin surface. In each case the essential condition of a shallow layer or film of liquid surrounding the larvæ was provided.

He also showed by his repetitions of experiments with stains and gelatine solutions, in extension of the work of Herman and Lambinet, that the larvæ could only escape from their sheaths when the surrounding conditions were suitable. In the presence of a stain the contained larva only broke out from the sheath when a coverslip was applied to the drop, and the distance between it and the slide was approximately twice the thickness of a larva. Later he found that exsheathment could take place without the stimulus supplied by a stain when the larvæ were in a drop of clean distilled water. In this case, however, it only happened when the distance between coverslip and slide was less than when a stain was employed. In the experiments with gelatine solutions he found that the sheaths surrounding the larvæ are held by the gelatine as it begins to congeal, and the contained larvæ are able to make their way out by active movements made against the sheath. In contrast with these results he found that ensheathed larvæ could be kept in a glass vessel in pure water free from foreign particles for a very long time without escaping from their sheaths.

He showed clearly that ecdysis is a mechanical process, and that certain physical conditions are essential for its accomplishment, viz., there

must be either some foreign particles present or a rough surface against which the larvæ can rub and secure a certain purchase, or the layer of liquid containing them must be sufficiently shallow or of such viscosity that the sheath is held back whilst the larvæ break their way out by active movements.

Apropos of these results, it is of interest to note that Augustine (1923) has repeated many of Looss' experiments on the conditions under which exsheathment of mature hookworm larvæ takes place, using larvæ of *Necator americanus* as his material. He has tested the effect of gelatine solutions, stains and water on them, and, on the whole, his results confirm those of Looss as to the mechanical character of the process of ecdysis. He has found, however, that the larvæ may escape from their sheaths when in pure water only, particularly when they are getting old and the sheath is presumably becoming more brittle than in younger forms, although it may occur even amongst these. He points out that this phenomenon had been observed earlier by Liefmann, but had not been confirmed by Looss. A year or two ago the writer (Goodey, 1922) devised a simple method for skin penetration work whereby the larvæ used can be observed on the surface of a piece of skin. The latter is stretched and pinned over a hole in the centre of a small raft of cork, which is floated on normal saline contained in a suitable glass vessel. The lower surface of the skin is in contact with the saline, and the hole in the cork allows of the illumination of the preparation from below, as the glass container can be placed on the microscope stage. By the use of this method it was found that infective larvæ of *Necator americanus* only left their sheaths and penetrated the skin when the drop containing them had almost dried up. Previous to this, and whilst the drop was still deep, they did not enter the skin, but could be seen in active movement with their heads downwardly directed pressing on the skin, especially at the edge of the drop.

Fülleborn (1914) published an account of several interesting and important experiments with infective larvæ of Ancylostomes and Strongyloides from a dog. Recently (1923 and 1924) the same investigator has published papers which deal with the reactions of Strongyloides and Ankylostome larvæ under various stimuli. The results of his numerous experiments are of fundamental importance in the elucidation of the behaviour and the biology of the infective larvæ.

Kosuge (1924 and 1924a), working in Fülleborn's laboratory, has published papers dealing with skin penetration of Strongyloides larvæ. In the former he shows that in the case of thin-skinned animals the route taken by the larvæ in entering the skin is by the epidermal scales, whereas in thick-skinned animals it is *viâ* the hair follicles.

In the second paper he shows that they can quickly penetrate moist paper of certain kinds and textures at laboratory temperature, and that they can enter skin of different animals, frog, mouse, and guinea-pig, both when cold and at body temperature. From this he concludes that the positive thermotropic reaction of the larvæ is not a prime cause of skin penetration and that Brumpt's "histiotropism" is negligible as a cause of skin penetration.

Fülleborn (1914), p. 44, points out that Looss concluded from his experiments that mature Ankylostome larvæ could not penetrate skin when in a liquid medium of considerable depth, and proceeds to an account of his own experiments whereby he tested this conclusion for the infective larvæ of *Ancylostomum caninum* and for the filariform larvæ of *Strongyloides stercoralis*. It will be convenient to deal with experiments on Strongyloides larvæ first.

Experiments with Strongyloides Larvæ.

His method of experimentation was as follows : An area on the abdomen of a guinea pig was shaved, and the shaved region was covered, except for a central circular portion about the size of a pfennig, with a resin and wax cement. This served to fasten to the skin a small inverted bell-jar and to render the junction watertight. The bell-jar was provided with an aperture at its rounded end through which liquid could be introduced. Water containing a rich suspension of filariform Strongyloides larvæ was put into the jar until it stood at a considerable depth on the skin, and it was left in contact with the latter for about 40 minutes. At the end of this time the liquid was withdrawn, and the surface of the underlying skin was repeatedly washed with alcohol to ensure that no larvæ were left on it. The skin was then removed and sectionised in a fresh condition, with the result that large numbers of larvæ were found in the tissues underneath the unvarnished area. This showed that they had been able to penetrate skin under deep water.

The writer has confirmed this result by using his cork raft apparatus in the following way. A portion of skin from the abdomen of a mouse, after being carefully shaved, washed and dried, was attached to the cork raft and floated on saline at 37° C., which was, as usual, brought into contact with the underside of the skin. A drop of water containing a large number of filariform larvæ of Strongyloides (sp. ?) from a culture of monkey's fæces was placed on the upper side of the skin. Within five minutes of the application of the drop many larvæ were seen actively swimming in the warm saline on which the cork was floating. The drop containing the larvæ was, of course, still quite deep, and it was very interesting to watch the behaviour of the larvæ through the microscope. They could be seen in very active movement within the drop, and one or two were actually seen to penetrate the skin in spite of their great motility. A larva was seen to approach the surface of the skin and apply its head end to it ; the body then gave two or three very rapid wriggling movements, almost too rapid to be followed, and disappeared from view into the skin. A colleague, Dr. H. H. Scott, also saw a larva disappear into the skin as he was examining the same preparation. Many of the larvæ remained in the skin and did not go through into the saline, as was afterwards proved when the skin was fixed and cleared in lactophenol. Experiments similar in all essentials to the above have been performed several times since, and one always finds that the larvæ enter the skin while the water surrounding them is still deep.

Penetration in an Upward Direction.

It was thought that the position of the larvæ relative to the skin might have some connection with their ability to penetrate it, and it was therefore decided to test whether they could penetrate skin not in a drop resting on the skin surface, but when in such a position that they would have to bore upwards in order to enter it. The experiment was carried out as follows : A piece of skin from the abdomen of a very young rat was stretched and tied over the open end of a test tube about 1 centimetre in diameter, and the edges of the skin were cemented to the sides of the tube with a strong cement. The other end of the tube had previously been opened out so as to allow of the introduction of normal saline into the tube to come in contact with the inner side of the skin. A very rich suspension

of filariform larvæ of *Strongyloides fülleborni* obtained in a culture of fæces from a Guinea baboon, was placed at the bottom of a small, straight-sided jar, and formed a layer of liquid about 5 mm. deep. The skin-covered end of the test-tube was next immersed in this to a depth of about 2 mm., so that the larvæ had to swim upwards about 3 mm. in order to reach the skin surface. The test tube was held in position by a suitable clamp. Saline at 37° C. was put into the tube to a depth of about 1 in., and from time to time the temperature was taken. By illuminating the jar behind and by examining the liquid through a binocular microscope placed horizontally, any upward movement of the larvæ could easily be observed. Such upward movement was, in fact, very marked, as the larvæ, being positively thermotropic, moved towards the warm skin surface in large numbers, and could be seen in active movement clustered against the skin. Actual penetration of individual larvæ was not observed as they were so abundant and so active, but that penetration actually did take place was shown when saline was removed from the inside of the tube by means of a clean pipette. Within 10 minutes of immersing the skin into the suspension larvæ were found swimming in the saline taken from the test tube. More warm saline was put into the tube, and after another five minutes was removed by pipetting and examined under the microscope, when many more larvæ were found in it. They were more numerous in the final drops of saline which were in immediate contact with the inside of the skin. At the end of half an hour the test tube was removed from the liquid, and the skin was cut out from the end. It was then fixed in hot 70 per cent. alcohol, and afterwards cleared in lactophenol, when numerous larvæ were found lying within it.

Two experiments of this character were performed on two different occasions, and each time with a similar result. There is, then, no doubt whatever that filariform larvæ of Strongyloides can penetrate skin when the surrounding liquid is quite deep, and that this can be accomplished both in a downward and in an upward direction.

Experiments with Ankylostome Larvæ.

In his experiment with the infective larvæ of *Ancylostomum caninum* Fülleborn (1914, p. 45) used a rich suspension, and applied them to the abdomen of a guinea pig, making use of the same apparatus in exactly the same manner as for the Strongyloides larvæ. They were left in con-

tact with the skin for an hour, after which the bell-jar was washed out twice with hot water, and the surface of the skin was finally seared with a hot spatula. Skin was removed and sectionised fresh, and after passing through to paraffin. In both lots of sections larvæ were found in the deeper layers of skin, and the conclusion was drawn that they had penetrated when in a deep layer of liquid. A footnote is appended to the account in which Fülleborn suggests that possibly the cement had become loosened at its free edge in contact with the skin, and that the larvæ, by making use of the slit thus provided, had found conditions suitable to enable them to effect an entry into the skin. He also suggests that if they could penetrate under these conditions they might also enter via the epidermal scales even when under water. The two sets of conditions are, however, scarcely comparable, for there is a great difference between a scale of epidermis and a thin layer of cement, and whereas the former would not, in all probability, afford the necessary conditions of strain or purchase requisite for skin penetration, the latter no doubt would provide such a buttress as would enable ensheathed larvæ to escape from their sheaths and enter the skin.

In the writer's work larvæ of *Ancylostomum caninum* were also used, and the experiment was so conducted that they were allowed to remain in a drop of water on the surface of the skin for several hours. During this time they were frequently observed in active movement, but none of them ever penetrated the skin. Details of the experiment are as follows: Abdominal skin from a mouse, after being carefully shaved, washed and dried, was attached to the cork raft in the usual way, and then floated on saline at 37° C. contained in a small cylindrical glass jar. A drop of water containing about 50 ensheathed larvæ of *A. caninum* was then placed on the surface of the skin, and the mouth of the containing jar was covered with a glass lid to prevent evaporation from the drop. The latter measured ¼ in. in diameter and had a height of 1-10th in., and did not tend to spread outwards on the skin. Its sides were consequently quite steep. The saline below the raft was maintained at a constant temperature of 36° C. throughout the experiment. The drop was first applied to the skin at 12.25 p.m. and twice during the course of the experiment, at 2.45 and 4 o'clock, a small drop of water was added to replenish the slight loss in bulk due to evaporation. At 5.25 p.m., *i.e.*, practically

five hours after commencing the experiment, the drop was sucked up from the skin and transferred to a shallow glass capsule for subsequent examination. The surface of the skin in the area of the drop was washed twice with distilled water, which was afterwards carefully pipetted off and added to the contents of the capsule. A careful examination of the skin was made, but no larvæ could be seen moving within it, and it was then fixed in hot alcohol and cleared the next day in creosote. When examined under the microscope no sign of larvæ could be made out within the skin ; in fact, they had not penetrated it. Examination of the drop removed from the surface of the skin showed all the larvæ in an active condition. There were also about 30 empty sheaths, which showed that although none of the larvæ had been able to enter the skin, many of them had at any rate been able to rub themselves out of their sheaths even in a deep layer of water. It may be mentioned in passing that the larvæ were quite normal and healthy and able to penetrate skin, as was proved on the previous day, when a number of them from the same culture were placed in a drop of water on shaved mouse skin, and the drop allowed to dry, when they entered the skin as was expected.

The above experiment proves that unsheathed larvæ of *A. caninum*, and presumably of other ankylostomes, cannot penetrate skin when in a deep layer of water, when the surface is normal, and when artificial fissures, such as Fülleborn's layer of cement would afford, are absent.

The fact that the sides of the drop were steep is important, as was shown by another similar experiment. In this case a drop of water containing about 200 ensheathed larvæ of a human hookworm, cultivated from the stool of a hospital patient, was placed on a floating raft preparation of very young rat skin. From time to time a small drop of clean water was added to make good the slight loss in bulk, but instead of the sides of the drop remaining steep, a spreading occurred at one side, and the drop became much shallower in this region. This was probably due to the large number of larvæ used and to their habit of assembling at the side of a drop and of boring outwards against the force exerted by the surface tension where liquid and substratum meet. This boring activity performed by a large number of larvæ in a drop would no doubt be sufficient to cause the edge of the liquid to spread outwards. When the experiment was terminated after the larvæ had been in contact with the skin for 6 hours 40 minutes, about 20 larvæ were found to have penetrated the skin in the

vicinity of the shallow side. A large number of empty sheaths were also found in the drop removed from the skin at the end of the experiment, which shows that extensive exsheathment had occurred even though comparatively few of the larvæ in the drop entered the skin.

Exsheathment unaccompanied by skin penetration may appear at first sight at variance with Looss' findings (1911, pp. 431-436), where particular stress is laid on the inability of larvæ to effect an ecdysis in a deep layer of liquid. It is necessary to remember, however, that in the present experiments the larvæ in the drop on the skin were in contact with a warm membrane towards which they were impelled by a positive thermotropic response. This membrane presented a roughish surface capable of affording them opportunities of rubbing themselves out of their sheaths. Accompanying the larvæ there were also numerous small fibres and particles washed from the blotting paper in the lids of the culture dishes. In Looss' experiments, on the other hand, the larvæ were kept for long periods in pure clean water or in dilute stains in glass vessels, and did not exsheath. In this case there would be no thermotropic movement causing them to rub against a surface, and they would naturally move freely in the lower layers of the liquid without being stimulated to undergo an ecdysis.

Skin Penetration of Exsheathed Larvæ.

Augustine (1922 and 1923) has shown that exsheathed larvæ of *Necator americanus* can penetrate skin and set up an infection in the proper host, the intensity of the infection being proportionate to the number of larvæ employed. It is of interest to inquire, therefore, whether such exsheathed larvæ require different environmental conditions to effect their entry from those which apply to ensheathed forms or whether the same conditions are required in both cases.

The experiments already described with the floating raft are relevant to this point, for it has been shown that in the case of the drop containing about 50 larvæ of *A. caninum* at least 30 empty sheaths were found in the drop which was removed after being in contact with the skin for five hours. None of the exsheathed larvæ had penetrated the skin, which shows that such larvæ cannot enter when surrounded by a deep layer of liquid, and there can be no doubt that a shallow layer of liquid is an essential environmental condition for penetration.

In Augustine's experimental infection with exsheathed larvæ a shallow layer of liquid was used as the following quotation shows : " Twenty-five larvæ of *Necator americanus* were placed on the forearm of a volunteer who had been examined previously, at various intervals, and found to harbour no intestinal worms. The larvæ were obtained from soil cultures seven days old, and were later recovered after losing their sheaths in moist sand in which they had been placed 24 hours previously. After the larvæ were applied to the arm, a moist bandage was placed over the infected area and fastened with adhesive tape. Within 20 minutes definite irritation was sensed, which continued for five days. The gauze was removed after one hour, and 19 distinct salmon-red lesions were counted where the larvæ had entered the skin." The application of the moist gauze bandage would, of course, flatten and spread the drop containing the larvæ, and under these conditions they would enter the skin.

It might, at first sight, seem possible that mature ancylostome larvæ, having once got rid of their sheaths and therefore apparently on an equal footing with the sheathless filariform larvæ of Strongyloides, would, like them, be able to penetrate skin under a deep layer of liquid. The foregoing results show, however, that this is not so, and that the conditions are different in the two cases. Ankylostome larvæ, even when free from their sheaths, still require a shallow layer or film of liquid to afford them the necessary physical conditions of strain and purchase to effect an entry into the skin.

Discussion.

In considering the behaviour of the infective larvæ of Strongyloides and Ankylostomes as skin penetrators, and in attempting to understand their reactions, certain points must be borne in mind. One of these is that there is a distinct structural difference between them, *i.e.*, the filariform larvæ of Strongyloides are sheathless and the Ankylostome larvæ are ensheathed. The general behaviour and reaction to a variety stimuli are similar in both cases as shown by Fülleborn (1914 and 1924), and the capacity to penetrate skin is not determined by the possession or non-possession of a sheath ; it is something much more fundamental in character. Nevertheless, in the matter of the facility or ease with which the act of skin penetration is accomplished one may reasonably suggest that the greater facility possessed by the Strongyloides larvæ is due, in part, at any rate, to their being sheathless, for it has been shown that they can enter skin

very rapidly both downwards and upwards in a considerable depth of water, whereas Ankylostome only enter the skin if the layer of water containing them is sufficiently shallow.

In this connection also may be mentioned the behaviour of the insect-borne infective stages of certain of the Filaria which are also skin penetrators (*vide* Fülleborn, 1913, p. 261. ; Bahr, 1912, p. 32 ; Connal and Connal, 1922, p. 84). The stages which occur in the proboscis sheath of the insect host also appear to be sheathless forms. It is difficult, however, to make quite certain of this point from the literature, for the figure of the almost mature larva of *F. bancrofti* shown by Fülleborn, 1913, p. 260, after Looss, is of an ensheathed form, whereas the photomicrographs of the infective stages of *F. philippinensis* shown by Ashburn and Craig, 1907, from the proboscis sheath of a mosquito certainly have the appearance of being sheathless. The writer has examined the mounted mouth parts of *Chrysops silacea* from which the infective larvæ of *Loa loa* are protruding, and these also appear to be sheathless forms.

As showing the rapidity with which these can penetrate skin, the following passage taken from Connal and Connal, loc. cit., p. 84, will serve as an illustration : " The worms arrive in a continuous stream on the skin. At once they begin to detach themselves from the general mass, and within 60 seconds all the individuals of a group have disappeared under the skin without having travelled over a greater area than a quarter of an inch."

Another sheathless larva which is known to be a skin penetrator is the infective stage of *Heligmosomum muris*, Yokogawa, 1920, a rat parasite. Yokogawa (1922) has investigated the larval development of this, and his figures of the infective stage show a form more closely resembling an Ankylostome larva in shape, structure and proportions than a filariform Strongyloides larva, except that it is without an enclosing sheath. It is said by Yokogawa to " penetrate very quickly and easily into the tissues," but at the present time we have no information as to whether it can enter skin like a filariform larva of Strongyloides under a considerable depth of water or whether it behaves like an Ankylostome larva and requires a shallow layer. It would be very interesting to settle this point, and the writer is hoping to carry out certain experiments to determine this and other points in its behaviour.

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On some new members of the Genus *Kiluluma* from the African Rhinoceros.

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In a recent study (1924) I have given an account of the genus *Kiluluma*, describing six species collected by Prof. Leiper from an African rhinoceros in Uganda, and have elucidated certain interesting points in its anatomy. A further study of the material has revealed the presence of four new species which form the basis of the present communication.

1.—Kiluluma goodeyi, sp. nov.

There were a large number of specimens belonging to both sexes in a very good state of preservation. The specific name is given in honour of Dr. Goodey, who has been a continuous source of help in this work.

The females are longer than the males and are 18-19 mm. long, while the males are only 15-17 mm. long. The body tapers slightly towards the extremities.

The cuticle is thick and distinctly annulated, each annulus being further marked by fine transverse striations. At the anterior end it is produced into a lobed mouth-collar presenting an irregular margin on its anterior face. It is separated from the body by a deeply notched cephalic groove. The submedian papillæ rest, as usual, on the mouth collar and have the typical character. The lateral papillæ open out anterior to the cephalic groove.

The cervical papillæ are situated behind the œsophageal region at a distance of ·93 mm. in the male and 1·07 mm. in the female from the anterior end. The total length of each is ·1 mm., including the flagellum.

The nerve ring is 0·35 mm. from the anterior end in the male and 0·4 mm. in the female.

The excretory pore is situated in front of the cervical papillæ, and is ·9 mm. in the male and ·98 mm. in the female from the anterior end.

The mouth is an oval aperture and leads into a shallow buccal cavity bounded by the buccal capsule composed of a stout cuticular material. Arising internally from the base of the capsule are a series of eight thick fleshy lips, each of which is produced into an outwardly curved flagelliform process. The outer edges of the lips are rounded off and curve backwards to join posteriorly with the body wall.

The œsophagus is club-shaped, having its greatest diameter of 0·31 mm. near its posterior end. In the region of the nerve ring it is very slightly constricted. The opening of the œsophagus into the buccal cavity is more dorsally situated, and leads into a short œsophageal funnel. Within the œsophagus the cuticular lining forms a spherical œsophageal bulb. Anteriorly the œsophagus is thrown into three conical outgrowths guarding its aperture into the buccal cavity, while posteriorly there are the usual œsophageo-intestinal valves. The cells of the intestine are fairly large and distinct, being full of granular materials.

Male Characters.

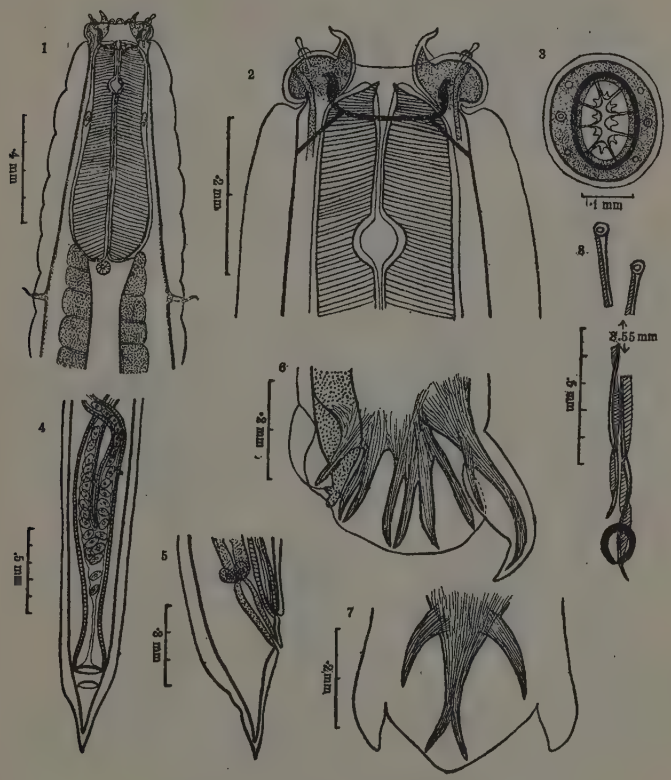
The bursa is well developed and its lobes are quite distinct. The dorsal lobe is longer than the lateral lobes and is slightly bent downwards. The bursal rays have the usual disposition. The pre-ventral ray is the first ray of the bursa on its ventral side. The lateral rays arise together by a stout common stem, and the extra-lateral ray separates off first from the series and the postero-lateral diverges from the rest. All the rays of the lateral lobe reach the edge of the bursa. The dorsal ray gives off the externo-dorsal ray near its base and itself bifurcates in its posterior quarter.

The genital cone is highly contractile, and is represented as being protruded out in Fig. 6, and the dermal cone is very prominent as in *K. rhinocerotis.*

The spicules are very long and narrow and bear along one of the margins a finely striated ala that coils round the axis of the spicule. The axis of the spicule is narrow and tapering towards the posterior extremity, where it is also spirally coiled. The ala in this part fills the hollow of the spicular axis and is absent near the tip. The length of the spicule is 9·5 mm. The ends of the spicules are shown in Fig. 8. The accessory piece is present and is oval in outline.

Female Characters.

The posterior end of the female gradually narrows and bears an elongated conical tail in continuation of its ventral side. The tail is ·24 mm. long.



Kiluluma goodeyi sp. n.

Fig. 1. Anterior end of the adult, ventral view.
Fig. 2. Head end, greatly enlarged, dorsal view.
Fig. 3. End-on view of head, showing papillæ, buccal capsule, lips, etc.
Fig. 4. Posterior part of female genitalia, ventral view.
Fig. 5. Tail of female, lateral view.
Fig. 6. Male bursa, lateral view.
Fig. 7. Same, dorsal view.
Fig. 8. Ends of spicules and accessory piece. 8·55 mm. indicates the length of the spicules left out.

The anus is ·43 mm. in front of the tip of the tail, and leads into a short rectum ·29 mm. long. It is lined with thick cuticle, and is delimited anteriorly from the intestine by the presence of three rectal ligaments.

The vulva is a wide opening ·11 mm. in advance of the anus, and leads into a short vagina about ·83 mm. long. The vaginal horns are very long, attaining the total length of 7·5-8 mm., and are the longest so far found in the genus, as are also the spicules. In their course forwards the vaginal horns are twisted round each other and are full of eggs.

The eggs are thin-walled, and measure ·09 mm. long by ·04 mm. broad.

2.—Kiluluma brevicauda, sp. nov.

The body is elongated cylindrically, narrowing slightly towards the extremities. The females are longer than the males and are 19 mm. long, the males are 18 mm. long.

The cuticle is thick, and shows distinct annulations throughout its length, each annulus being further marked by very fine striations. Anteriorly there is the usual mouth-collar, which is rather flattened out and is separated from the body by a distinct cephalic groove. The circum-oral papillæ stand out on the anterior face of the mouth-collar and have the usual characters. The lateral papillæ, however, open in the cephalic groove.

The cervical papillæ are post-œsophageal in position and have the common characters. They lie at a distance of ·96 mm. from the anterior end and each has the total length of ·1 mm.

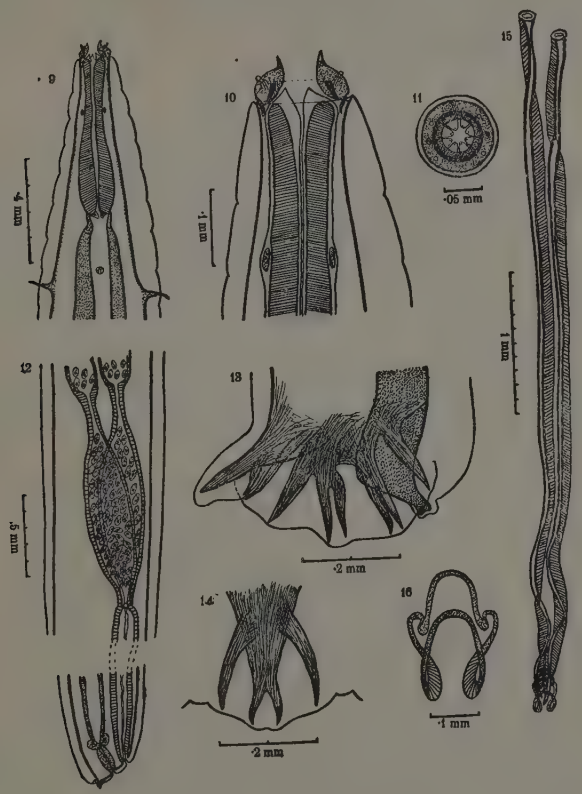
The excretory pore is ventrally situated in front of the cervical papillæ about ·86 mm. from the anterior end.

The nerve ring surrounds the œsophagus in the anterior region, and is ·265 mm. in the male and ·31 mm. in the female from the anterior end.

The mouth opening is surrounded by eight lips, the anterior ends of which are thrown out into anterior pointed processes. The buccal capsule is composed of a strong cuticular ring with broad truncated anterior end, and is twice as broad as deep. It is circular in outline.

The œsophagus is an elongated club-shaped structure 0·71 mm. long in the female and 0·63 mm. in the male. It is slightly constricted off in the region of the nerve ring, and swells out posteriorly into a larger bulb

with its maximum diameter of ·15 mm. Anteriorly the cuticular lining of the œsophagus is produced into three conical teeth which project into the buccal cavity. The œsophageal funnel is small, conical, and the



Kiluluma brevicauda sp. n.

Fig. 9. Anterior end, ventral view.
Fig. 10. Head end, greatly enlarged, dorsal view.
Fig. 11. End-on view of head.
Fig. 12. Posterior end of female, lateral view showing part of the genitalia. Vagina is partly not shown.
Fig. 13. Male bursa, lateral view.
Fig. 14. Same, dorsal view.
Fig. 15. Spicules and accessory piece.
Fig. 16. Accessory piece, greatly enlarged, ventral view.

opening is in the centre of the buccal cavity. There are the three usual œsophageo-intestinal valves present at the junction of the œsophagus with the intestine. The intestinal cells are not so distinctly recognisable as in the previous species, and the rectal ligaments occur at the junction of the rectum with the intestine.

Male Characters.

The bursa is well developed, and the dorsal lobe is small and distinct. It slightly overlaps the lateral lobe on either side, from which it is separated by a groove. The bursal rays are stout and have the usual disposition. The preventral ray lies within the bursa. The extra-lateral ray arises independently from the body wall, and has no connection with the lateral series of the rays. The postero-lateral diverges from the externo-lateral and medio-lateral rays which run together side by side. The dorsal ray is very stout at the base and gives off an externo-dorsal ray shortly after its origin from the body wall. The two branches of the dorsal ray are formed at its posterior fourth.

The genital cone has the usual characters and the dermal collar is present.

The spicules are alate and bear a winglike expansion along one edge. The ala follows the spiral coil of the anterior and posterior end of each spicule. The accessory piece is of a peculiar shape. Beginning from behind, it consists of a curved spurlike structure resembling the merry thought of the bird lying in the ventral wall of the cloaca, the apex of the spur extends anteriorly, and the hinder points of the spur turn upwards and forwards laterally in the cloacal wall. Near the anterior end of the cloaca the lateral outgrowths turn backwards dorsally and are continuous with another spurlike process in the anterior dorsal wall of the cloaca, thus becoming a completely closed structure throughout. The lateral pieces near their origin from the ventral spur are transversely striated. This structure on closer examination appears to resemble the " telamon " described by Hall (1921) in Hyostrongylus rubidus. The only difference seems to be that in the present case it has got an additional spurlike process in the dorsal wall of the cloaca. Probably here the gubernaculum has become fused with the telamon of Hall.

Female Characters.

The posterior end of the female tapers slightly and terminates dorsally into a short telescopic tail about ·06 mm. long. The body abruptly slopes down from the base of the tail to the genital aperture, thus giving this extremity of the worm an obliquely truncated appearance.

The anus is 0·13 mm. from the tip of the tail, and leads into a short rectum 0·25 mm. long. The rectum is lined internally by a thick cuticle.

The vulva is situated very close to the anus, and is 0·24 mm. in front of the tip of the tail. The vagina is 3·27 mm. long, and is lined with stout cuticle. It leads anteriorly into two horns formed by its bifurcation. The horns are short as compared with the length of the vagina, being only 1·35 mm. long, and are full of eggs.

The eggs are elongated, thin-walled and measure 0·08 mm. by 0·035mm.

3.—Kiluluma brevivaginata, sp. nov.

The females are 19 mm. long and males are shorter than this, being only 14-15 mm. in length. The worms in both the sexes taper towards the extremities.

The cuticle is thick and slightly inflated round the œsophageal region of the body. It is distinctly annulated, and each annulus is further finely striated. Of all the grooves that segment the body of the worms of this species there are two that stand out distinctly. The first groove separates the mouth-collar from the rest of the body as the cephalic groove ; the second groove is further down on the body and is very deeply marked. It bears the opening of the excretory apparatus in the mid-ventral line.

The mouth-collar is distinct and is lobed on its anterior face. It bears the sub-median papillæ in the usual position. The lateral papillæ open at the cephalic groove.

The cervical papillæ have the usual characters and are situated in the œsophageal region about 0·86 mm. in the male and 0·95 mm. in the female from the anterior end. They are flagelliform in nature and are ·09 mm. long.

The nerve ring is 0·43 mm. from the anterior end of the body.

The excretory pore is in front of the cervical papillæ about ·75 mm. from the anterior extremity of the body. As has been previously remarked, it is situated in a well-marked groove in the cuticle.

The mouth is circular and is surrounded by four lips, each bearing two cuticular-pointed leaf crowns. The buccal cavity is wide and a little broader than deep ; its walls are supported by a thick cuticular buccal capsule.

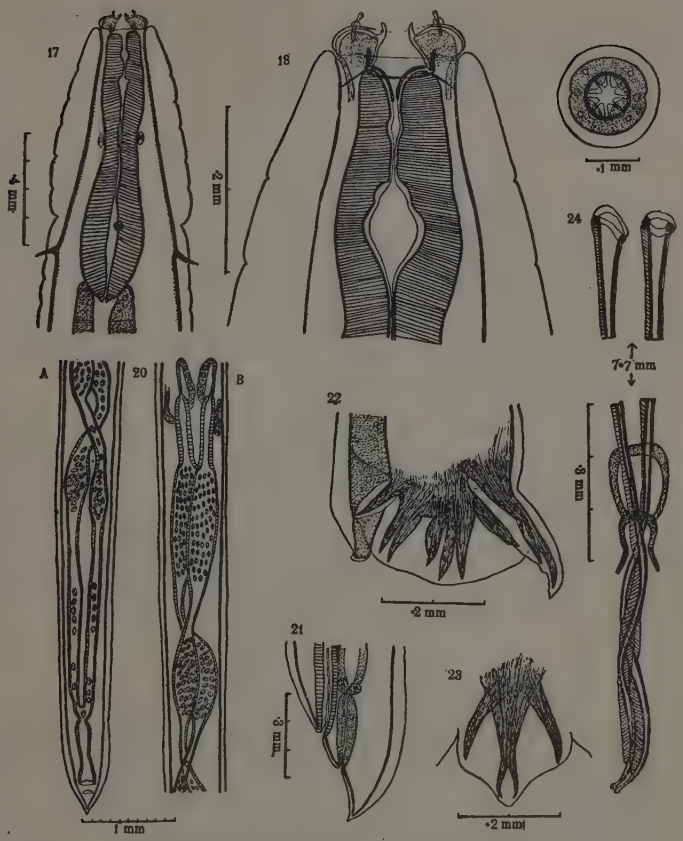
The œsophagus is elongated as in K. magna, and is slightly swollen out in front of the nerve ring, and has a larger swelling, having the maximum diameter of 0·22 mm. behind the nerve ring. The œsophageal funnel is very characteristic in this species, and is strengthened by a thick cuticular lining. At about ·12 mm. from the anterior end of the œsophagus the cuticular lining is folded to form a small oval cavity, and a little behind this it enlarges into another larger cavity of an irregular shape. There are the usual œsophageo-intestinal valves, and the intestinal cells are fairly large and full of granules.

Male Characters.

The bursa in this species shows a very well marked resemblance with that of the *K. goodeyi*. The bursal lobes are quite distinct, and the dorsal lobe slightly overlaps the laterals. The peculiar character of the bursa in this species is that the preventral ray appears to be stouter at the base than in the other species, and sometimes bears a part of the bursal lobe which is apparently separated from the lateral lobe by a shallow groove. Fig. 22 indicates the separation of this piece in the bursa. The other rays of the lateral lobe are also stouter at the base and pointed at the tips. Of the ventral rays the latero-ventral is the stouter of the two. The externo-lateral and the extra-lateral rays of the lateral series do not reach the edge of the bursa. The externo-lateral, the medio-lateral and the postero-lateral rays all run parallel to each other, and the extra-lateral ray diverges sharply from the lateral series. The dorsal ray has the common characters. It gives off the externo-dorsal ray near its origin from the body wall, and itself bifurcates in its posterior fourth.

The genital cone is contractile and has well-developed dermal collar.

The spicules are very long and narrow and attain the length of 8·7 mm. The axis of the spicule gradually tapers towards the posterior end, where it is spirally coiled. The alar expansion is of the usual type, and is spirally twisted round the spicular axis occupying the hollow of the spire in the posterior part of the axis. The tips of the spicules are rounded.



Kiluluma brevivaginata sp. n.

Fig. 17. Anterior end, ventral view.
Fig. 18. Same, greatly enlarged, dorsal view.
Fig. 19. End-on view of head.
Fig. 20. Female genitalia.
A. Showing vagina and posterior part of the horns.
B. Continuation forwards of the same, showing anterior part of the horns and uteri short and the beginning of the ovaries.
Fig. 21. Tail end of female, lateral view.
Fig. 22. Male bursa, lateral view.
Fig. 23. Same, dorsal view.
Fig. 24. Spicules and accessory piece. Figures 7·7 mm. indicates the length left out in the drawing.

The accessory piece is of a double character. The anterior part consists of an oval ring from the posterior edge of which arises on either side a rodlike process bent somewhat like a knee-joint.

Female Characters.

The female is peculiarly shaped at its posterior extremity. Beginning from a little in front of the vaginal orifice, the body wall gradually tapers towards the dorsal side till it ends posteriorly in a slightly bent pointed tip. The tail in this species is, therefore, to be considered as the whole of the body behind the anus, which is ·2 mm. from the tip of the tail. The rectum is short and is ·28 mm. long. The rectal ligament cells are of the usual character and mark the anterior limit of the rectum.

The vulva is ·35 mm. from the tip of the tail and leads into a very short vagina on which character the specific name is based, measuring ·7 mm. in length. The horns of the vagina are very long and possess several swellings full of eggs in their course forwards. Each horn is 7·4 mm. long, and leads into an extremely short uterus ·8 mm. long. In this species the uteri are also the shortest so far observed.

The eggs measure ·08 mm. by ·05 mm. and are thin-shelled.

4.—Kiluluma cylindrica, sp. nov.

There were several specimens belonging to this species, a few of which were in a very good state of preservation to afford an adequate study of the material.

The females are, as in every other species, slightly longer than the males; their relative lengths are: females 12 mm. and males 11 mm. The body is approximately of a uniform diameter throughout, only slightly narrowing in the females at the posterior end.

The cuticle is thick, especially at the anterior end, where it is inflated to give the worm a cylindrical appearance. In this region the cuticle presents a double contour as far back as the nerve ring. The inner layer of the cuticle slopes slightly inwards anteriorly, and corresponds to the usual cuticle in other species; the outer layer of cuticle is thickened as it

proceeds towards the anterior end, thereby making the body appear cylindrical. Anteriorly the inner layer of cuticle is produced forwards to form the mouth-collar, which is indistinctly marked off from the lips. It is produced into four lobes on its anterior face, where it bears the submedian papillæ in the usual position. Posteriorly the mouth-collar is separated from the body wall by a distinct cephalic groove. The lateral papillæ are situated a little in front of the cephalic groove, and the submedian papillæ pierce through the lips and are without the collarlike basal expansion found in other species of the genus.

The cervical papillæ are very slender. Each has a total length of ·07 mm. and they are situated in the post-œsophageal region about 0·73 mm. in the male and 0·74 mm. in the female from the anterior end.

The nerve ring is ·2 mm. from the anterior end in the male and ·22 mm. in the female.

The excretory pore is in front of the cervical papillæ and is ·68-·7 mm. from the anterior end.

The mouth opening is circular and is surrounded by six lips arising from the inner side of the base of the buccal capsule. Anteriorly the lips are produced into short pointed outgrowths along their inner side, while the outer end is rounded off to join the body wall.

The buccal cavity is circular in outline and is surrounded by the thick cuticular ring of the buccal capsule. The capsule is thickest in its middle and gradually narrows posteriorly.

The œsophagus is an elongated club-shaped structure with its maximum diameter of ·09 mm. towards its posterior end. Its cuticular lining is thrown out anteriorly into three short conical teethlike processes within the buccal cavity, and the outer anterior margin is slightly protruded forwards along the outer edge of the buccal capsule for a short distance and probably supports the latter. The œsophageal funnel is very small and at ·03 mm. from the anterior end of the œsophagus its cuticular lining is folded out to form an oval bulb within the œsophagus. The œsophageo-intestinal valves are small and have the usual disposition. The intestine is cylindrical and its lumen is lined by a thick cuticle. The intestinal cells are full of fine granules.

Male Characters.

The bursa is divisible into three lobes and the dorsal lobe is equal to the lateral lobe in length. The bursal rays have the common disposition of parts and are relatively long and narrow. The preventral ray is slightly curved and the common stem of the ventral rays is rather longer than in the other species. Of the lateral rays the postero-lateral is the stoutest of the series. The extra-lateral ray arises from the common stem of the lateral series. The dorsal ray gives off the externo-dorsal ray at its anterior third, and itself divides into two branches in its posterior third. The externo-dorsal ray, after a short course, gives off a small narrow branch on its inner side, and itself continues backwards to reach the edge of the bursa. The branch of the externo-dorsal ray curves outwards and its tip lies beneath the externo-dorsal proper.

The genital cone is contractile, as in other species, and there is a well-developed dermal collar present.

The spicules are equal and similar, and attain the length of 1·8 mm. The head end is flanged out, and the axis tapers to its extremity. It has the maximum diameter of ·05 mm. In the posterior fourth of its length the axis is coiled like an open corkscrew. Running along one of its edges there is a transversely striated cuticular alar expansion, which, in the spiral portion of the axis, coils with the spiral twist of the spicular axis and fills up the hollow of the spire. The ends of the spicules are, as usual, devoid of the alar expansion.

The accessory piece is ring-shaped, and is produced back into two lateral processes running in the lateral wall of the cloaca. (Fig. 32.)

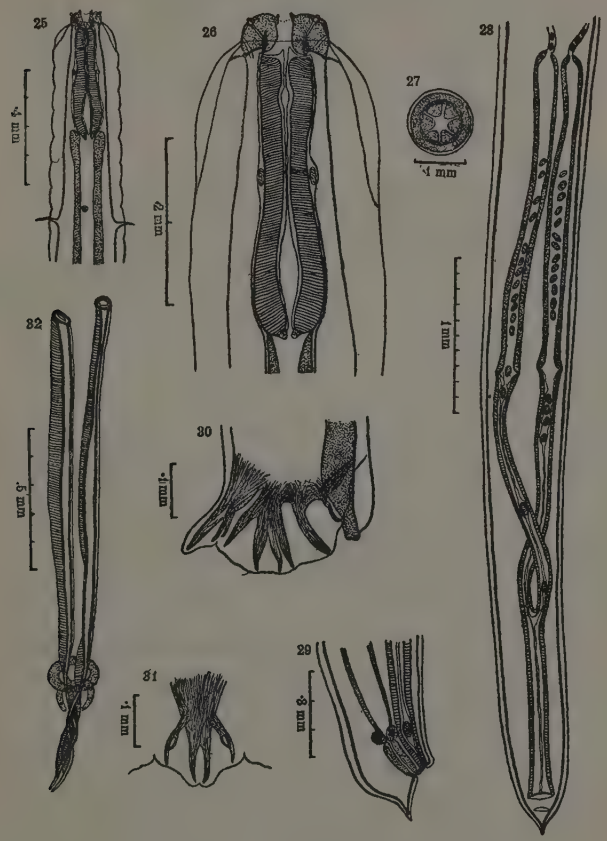
Female Characters.

The body of the female narrows slightly towards the extreme posterior end, where it rounds itself off and bears at its extremity a short conical tail.

The anus is ·16 mm. from the tip of the tail and is continued into a short rectum about ·16 mm. long, which is lined by thick cuticle. Anteriorly the rectum is limited by three rectal cells which mark the position of its connection with the intestine.

The vulva is situated very close to the anus, being only ·04 mm. in front of it, and has a prominent ventral lip. The vagina is forwardly

directed and is 1·18 mm. long. It bifurcates anteriorly into its two vaginal horns that are a little longer than the vagina itself, being 1·64 mm.



Kiluluma cylindrica sp. n.

Fig. 25. Anterior end, ventral view.
Fig. 26. Dorsal view of the same, greatly enlarged.
Fig. 27. End-on view of head.
Fig. 28. Female genitalia, ventral view. Ovaries are left out.
Fig. 29. Tail of female, lateral view.
Fig. 30. Male bursa, lateral view.
Fig. 31. Same, dorsal view.
Fig. 32. Spicules and accessory piece.

in length. They coil round each other in their course forward. The uteri are also long, in fact longer than either of the above two described structures, and attain a length of 2 mm. Both the horns of the vagina and the uteri are full of eggs arranged in linear series.

The eggs are elongated, thin-shelled structures and measure ·09 mm. long and ·05 mm. broad.

Discussion.

In my previous communication (1924) I discussed a few points of systematic importance and suggested the creation of a new sub-family, Kiluluminæ, for the reception of the genus *Kiluluma*. The present study further confirms the conclusions arrived at in that communication, and throws some further light on the morphology of certain structures, the discussion of which seems necessary.

First of all, we take up the consideration of the structure described under the name " accessory piece." This structure is formed, as is well known, from the cuticular thickening of the cloacal wall, and assumes various shapes and forms in different nematodes. Thus, in the genera *Mehdiella* and *Tachygonetria* amongst the Oxyuridæ it is found to have the form of a wide V, while in the genus *Œsophagostomum* it is an elongated structure shaped like a small coal shovel. In certain genera of Strongylid parasites it is in the form of a simple rodlike structure, and in others it may be a curved rod. In the genus under discussion we find that whereas in different species it differs in minor details, it is based on a common plan of structure from which the condition in each species could be derived by slight modification. Hall (1921) has introduced a new term, " telamon," for a structure found within the cloaca near its external opening. It is of a variable form in the nematodes belonging to different genera and species. He distinguishes it from the structure known as gubernaculum, which he restricts for the longitudinal structure in the wall of the cloaca along its dorsal anterior aspect, while the telamon is regarded by him as a support for the posterior end of the cloaca. Both of these structures are formed by the cuticularisation of the cloacal wall. This distinction seems quite valid when there are two independent structures present, but when there is only one of these found it is very difficult to decide about its

nomenclature. Let us take the description of telamon in *Hyostrongylus rubidus*. Beginning from the posterior end, we find there is a curved spurlike cuticular structure whose apex is directed forwards. The posterior ends of this spur are turned laterally upwards towards the anterior end as elongated processes, one on either side in the cloacal wall. In addition there is an elongated gubernaculum. In the genus *Kilulurna* the common type of structure present has the shape of an anterior transverse bar on the dorsal wall of the cloaca, and it is turned laterally backwards to assume varying forms in different species. In one of the species described in this communication as *Kilulurna brevicauda* the accessory piece is exactly similar to the telamon of *Hyostrongylus rubidus*, the only difference being that in *K. brevicauda* the lateral processes are slightly curved backwards at their anterior extremities and from the ends arise another spurlike process situated in the dorsal wall of the cloaca, thereby making it a completely closed structure of an irregular shape. It appears that in this form the gubernaculum has become fused with the telamon, and thus it could be compared to both the telamon and the gubernaculum of *Hyostrongylus rubidus*. In other forms it is found in the anterior part of the cloaca, and therefore cannot be compared, according to its position in the cloaca, to the telamon, though it is circular and somewhat obliquely placed within the cloaca like the telamon. Further, in some species of Kilulurna the accessory piece, after forming a complete ring-shaped structure, sends out, in the lateral wall of the cloaca, a posterior process on either side. It would, therefore, be not an easy matter to decide about the exact nomenclature of these two structures. Both gubernaculum and telamon are the local thickenings of the cloacal wall formed by the aggregation of the cuticular material at different places, and are meant to protect the cloacal wall from the sharp-pointed spicules for which they serve, in addition, as guides. It may well be mentioned that it would be safe to restrict the term " accessory piece " when the structure is alone, and when there are both, the terms " gubernaculum " and " telamon " be used, as suggested by Hall, according to their relative position within the cloaca.

Another point deserving attention is the relation between the relative lengths of the spicules and vagina. We find that these structures vary in length in different species ; where spicules are short the length of the

vagina corresponds to it, and where the spicules are long the length of the vagina increases accordingly. This relation between the two structures was pointed out by Goodey (1924) in the genus *Œsophagostomum*. While studying the genus *Kiluluma* the writer has made certain observations that indicate that this relationship between the spicules and the vagina does not always exist. In the following species of the genus in question the relation seems to be fairly constant.

	Spicules.	*Vagina.*
K. pachyderma	1·95 mm.	1· 6 mm.
K. solitaria	1· 9 mm.	1·32 mm.
K. cylindrica	1· 8 mm.	1·18 mm.

This indicates that the length of the vagina varies approximately with the variations in the length of the spicules. But the case is different in the following species of the genus *Kiluluma*, though the correspondence of the relative length of the two structures is, in my opinion, apparent.

The species in which this correspondence does not exist are *K. rhinocerotis*, *K. brevivaginata*, *K. goodeyi*, and *K. brevicauda*. Here the relationship does not hold as expressed by Goodey. From a consideration of the morphology of the female genitalia of these forms and other species it appears that the vagina in the genus *Kiluluma* divides into its two horns anteriorly and these horns attain a variable length in different species and then lead into the corresponding uterus. There are no ovejectors, as are found in the genus *Œsophagostomum* and certain other Strongylids. The horns of the vagina have, as has been stated, a similar constitution of the wall to that of the vagina, and differ from that of the uterus into which they lead or from that of the ovejectors of other Strongylids. Consequently, both vagina and the horns of the vagina are to be considered together as one structure. The horns are simply the anterior portions of the vagina that has split up into two branches like the bicornuate uterus of the mammals. If we accept this hypothesis we can proceed further to consider the relationship between the vagina and the spicules, in the species in question.

	Spicules.	*Vagina.*	*Horns.*
K. rhinocerotis	2·1 mm.	0·87 mm.	0·78 mm.
K. goodeyi ...	9·5 mm.	0·83 mm.	7· 5 mm.
K. brevicauda	4·9 mm.	3·27 mm.	1·35 mm.
K. brevivaginata	8·7 mm.	0· 7 mm.	7· 5 mm.

In taking the total length of the vagina and the horns we find that it accords with the variations in the length of the spicules themselves. Thus, where the spicules are 4·9 mm. long, as in *Kiluluma brevicauda*, the vagina with its horns measures 4·62 mm., and when the spicules are longer, as in *Kiluluma goodeyi*, they are 9·5 mm. long, the total length of the vagina and its horn has increased to 8·33 mm. Similarly we can trace a like correspondence in other species of the genus. Therefore we can modify the general statement for this genus thus :—

" The length of the spicule ordinarily corresponds to the length of the vagina, and where this relation does not hold it will be found that the length of the spicules varies with the total length of the vagina and its horn taken together."

This relation seems to be of importance in the isolation of species from one another.

In conclusion, I wish to express my indebtedness to Prof. R. T. Leiper, F.R.S., and Dr. T. Goodey for the constant help and encouragement received from them in the course of this work.

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Starlings as Distributors of "Gapes."

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"Gapes," a disease of Poultry caused by the presence of *Syngamus trachealis* in the windpipe, is a common disease in the Aberystwyth area, and is generally known among the Welsh farmers and poultry-keepers as "Clefyd-y-big" (the disease of the beak).

In 1920, R. H. Waite published a paper on "Earthworms—The Important Factor in the Transmission of Gapes in Chickens," in which he claimed that earthworms ingest the eggs and embryos of *S. trachealis* which have contaminated the soil of an infected area, and thus help to transmit the disease to other non-infected birds, which swallow the infected earthworms. Numerous investigators have dealt with the question of "Gapes," but none have attached much importance to the fact that *S. trachealis* also occurs in wild birds.

In 1837, Nathusius records *S. trachealis* from a Starling in Germany; Dujardin (1845) found five pairs of this worm in the tracheæ of two magpies (*Corvus pica*) at Rennes; and Megnin (1883) states that this parasite was discovered in the tracheæ of the swift (*Cypselus apus*), starling (*Sturnus vulgaris*), green-woodpecker (*Picus viridis*), pheasant (*Phasianus gallus*) common partridge (*Perdix cinerea*): and the black stork (*Ciconia nigra*). Megnin also states that "in various pheasantries of Central France, as well as around Paris, where this terrible epidemic has made thousands of victims that the parasite that causes it is no other than *S. trachealis*." H. D. Walker (1886) makes the statement, "That the robin (*Turdus migratorius*), may act as a host for *Syngamus*, and thus be instrumental in spreading the disease, ..."

The Ministry of Agriculture & Fisheries' Leaflet No. 58, adds the following list of birds which harbour *Syngamus*:—

"Sparrow, Linnet and Rook."

In this area I have found *S. trachealis* in starlings, rook (*Corvus frugilegus*, Linn.), thrush (*Turdus musicus*, Linn.),and jay (*Garrulus glandarius*, Linn.); and I am of the opinion that not sufficient importance has been attached to the occurrence of this parasite in wild birds, and especially in the starling.

I have been much impressed by the fact that starlings harbour *S. trachealis* to a high percentage; and that they are infected much more often than any other wild bird. The number of starlings examined was thirty-eight. Of these fourteen were infected. Ten contained one worm each; the other four, two worms each. Thus, of the starlings examined nearly 37 per cent. were infected with *S. trachealis*.

On looking into the habits and migration of starlings, one finds that some inhabit Britain throughout the year. These migrate within a small area, or to far wider, and entirely different localities within the Island; others—and these are very numerous—migrate, in Autumn, from Central Europe (including Central France) to the British Isles, and, in Spring, make their way back to the Continent from where they came.

If starlings are invaded by *S. trachealis* to a high percentage, then, bearing in mind the migrations of this bird, and the facts that "Gapes" is not uncommon in Britain, and that the Pheasantries of France (now much reduced by the War) were hotbeds of "Gapes," it is not unreasonable to suggest that the starling is, and has been, an important factor in keeping up the ravages of "Gapes," and in distributing the disease to very wide areas.

I am at present collecting further material with a view to testing the validity of the views put forward above.

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Studies on the Oxyurid Parasites of Reptiles.

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The Oxyurid parasites of Reptiles form a group of very interesting forms and have been a subject of study by several distinguished helminthologists from early times. The earliest account, in a connected form, to which the writer has been able to refer is that given by Rudolphi (1819). This author, though recognising the genus Oxyuris, restricts to it the forms found in mammals and more particularly *Oxyuris vermicularis* from the large intestine of man and *Oxyuris curvula* from the cæcum of horse ; the Oxyurids of all other animals he refers to the genus Ascaris.

This misnomer prevailed until Dujardin (1845), on re-investigation of the parasitic Nematodes, removed a number of known forms of Ascaris to the genus Oxyuris. Thus, he transferred Rudolphi's *Ascaris extenuata*, a nematode from the cæcum of *Lacerta muralis*, to *Oxyuris spinicauda*, and described a new species, *Oxyuris brevicauda*, from the intestine of a Gecko. He also erected a new genus, *Atractis*, to include Rudolphi's *Ascaris dactylura* from *Testudo græca* (*ibera*). He still referred the other forms to the genus Ascaris.

Diesing (1851) while dealing with non-bursate nematodes with three lips from reptilian hosts, especially Rudolphi's forms of Ascaris from reptiles, distributed them amongst three genera, *Ascaris*, *Oxyuris* and *Atractis*. He also described a new species of Atractis from *Podocnemis erythrocephala* under the title, *Atractis hystrix*. His new species of Oxyuris, obtained from *Chrysolamprus ocellatus*, was designated *Oxyuris acanthura* (= *O. spinicauda* Dujardin, 1845). Later (1861) he created a new genus —*Pharyngodon*—for its reception. This species has since been reported from several other reptilian hosts from different localities.

Schlotthauber (1860) described several species, including three new forms under the genus *Oxyuris*, which he considered as being distinct from the genus *Oxyuris* of Rudolphi. To his new genus Schlotthauber designated the forms *vermicularis, alata, obvelata, brachyura, brevicauda, dispar, brevicaudata,* and *leptocephala,* and added *spinicauda, acuminata,* and *gracilis* as new species to it. He removed Oxyuris of the horse from the genus *Oxyuris* and made a special genus—*Lepturus*—for its reception. This gave a stimulus for further investigation on the Oxyurids which were consequently split up into several genera.

Of the reptilian Oxyurids, Diesing (1861) created a new genus *Pharyngodon* for his species originally described as *O. acanthura.* The following year Wedl (1862) studied the Oxyurids of *Uromastix spinipes* from Egypt, and founded two new genera, *Thelandros* and *Tachygonetria,* basing his diagnosis on the presence or absence of an accessory piece in the male. These two genera of Wedl differed primarily from Diesing's *Pharyngodon* in having the female genital opening in the posterior half, while in the genus *Pharyngodon* it is in the anterior half of the body. Thus, we get four distinct genera of Oxyurids—*Atractis, Pharyngodon, Thelandros* and *Tachygonetria* from reptiles. It may, however, be pointed out that the original genus, *Oxyuris,* was still recognised, and later workers have referred a large number of species to it. Thus, Schneider (1866) named *Oxyuris longicollis* from *Testudo ibera* under it. He also erected a new genus—*Labiduris*—for *Ascaris gulosa* Rud. from *Testudo tabulata.* This genus of Schneider was later on classed by Railliet and Henry (1916) along with other genera in the family *Oxyuridæ.*

Drasche (1884) gave a brief account, with a few figures, of seven species of *Oxyuris* from *Testudo græca* (*ibera*). Out of these, six were new to science. Both he and Schneider recognised Dujardin's genus *Atractis.*

Von Linstow (1883-1908), in a series of very valuable contributions, added considerably to the parasitic fauna of reptiles and described many new species of Oxyurids from these hosts.

Galeb (1878) added a new species—*O. uromasticola*—from *Uromastix acanthura.*

Smith (1908) gives an account of a new form of Oxyurid from *Cyclura nubila* under the title *O. microtyphlon.* Seurat (1912-14) described a few

Oxyurids from reptiles including a new species, *O. lævicauda*, from the rectum of *Acanthodactylus blanci* and *Scincus officinalis*, and has given several illustrations to elucidate his descriptions of these forms.

Skrjabin (1916), while studying the helminths from British East Africa, gave an account of a new Oxyurid, *O. megalocerca*, from the cæcum of a species of Geckonidæ (?) This species has subsequently been put into the genus *Pharyngodon* by Baylis (1923).

It would thus appear that the distribution of Oxyurids into the different genera was a matter of individual taste, until Railliet and Henry (1916) gave a classification as an identification table for the determination of the *Oxyuridæ*, and added a list of genera under each of the sub-divisions. They recognised the following groups, though at this stage they did not give them any definite names :—

1. Forms with one spicule only.
2. Forms with one spicule and an accessory piece.
3. Forms with two equal spicules.
4. Forms with two equal spicules and an accessory piece.
5. Forms with two unequal spicules and accessory piece.

These investigators raised the family *Oxyuridæ* to the status of a superfamily naming it *Oxyuroidea*.

Travassos (1920) in giving the general key for the identification of parasitic Nematodes recognised the superfamily *Oxyuroidea* and divided it into several families, some with subfamilies having several genera in each. He classified the Oxyurids from reptiles into a family *Pharyngodonidæ* and included in it the genera *Pharyngodon*, *Tachygonetria* and *Thelandros*. He, however, redistributed several genera originally classified by Railliet and Henry (1916) under the family *Oxyuridæ*, and removed several from even the superfamily *Oxyuroidea*.

The latest, and perhaps the most important, addition to the literature on the group of Oxyurids from reptiles are the contributions of Seurat. He, in his earlier works (1912-15), referred them all to the genus *Oxyuris*. Later he reviewed the Oxyurids from North African reptiles in two communications. In his first paper (1917) he has given an account of the genera *Pharyngodon* and *Thelandros*, describing several species of each and giving a brief account of *Tachygonetria vivipara*. He did,

however, not clearly indicate the generic distinctions between *Tachygonetria* and *Thelandros* beyond the difference in the presence or absence of the accessory piece. This difference alone, as will be referred to later on, is not of sufficient merit to differentiate the genera. In his second communication (1918) he described the Nematode fauna of Tunis and gave, besides many other forms, an account of the genus *Tachygonetria*, describing many species, including some new forms. He also founded a new genus *Mehdiella* and described two species, *M. microstoma* and *M. uncinata*, under this genus, the former representing the type. The type species of *Mehdiella*, it may be pointed out, has no marked differences from the type of the genus *Tachygonetria*; at least I have not been able to discover any from the descriptions of Seurat. Further examination of specimens of the type species showed the only differences to be in the presence of minute spines in the œsophageal bulb of *M. microstoma*. This point has been omitted in Seurat's description; probably it was overlooked by him. This character cannot, however, be regarded as of generic value because no spines are present in the other species assigned to it. Seurat, in a later communication (1918) states that in the genus *Mehdiella* "la région postérieure du corps se prolonge, dans les deux sexes, au delà de l'anus, en une queue conique, robuste, ornée chez le mâle, vers son tiers antérieur, d'une paire de volumineuses papilles latéro-ventrales, en outre (*M. uncinata*), la cuticle détachée au niveau de la région cloacale du mâle donne lieu à deux ailes caudales étroites, chez les *Tachygonetria* . . . on assiste à un curieux phénomène de réduction et de disparition de la pointe caudale : chez tous la queue est brusquement coupée à la hauteur des papilles génitales de la première paire, en sorte que, vue de face, elle apparaît trapézoïdale ; . . . dans les autres détails de son organisation, ailes caudales, papilles génitales, spicule, gorgeret en V très ouvert, la queue du mâle est identique chez les deux genres." Thus, the only difference between the two genera, according to Seurat, concerns the caudal point and the position of the caudal papillæ on the tail. These differences do not seem valid when we find Seurat himself has described several species, some as new, of the genus *Tachygonetria* where these characters are mentioned as of a specific nature. He regards them as transitional forms between the two genera. The account itself begs the question. I, therefore, regard the two

generic names as synonyms and bring both the species described by Seurat under *Mehdiella* back into the older genus *Tachygonetria*.

Seurat has, in both of his communications, given a very useful key for the identification of these worms and has given synonyms of the various species described, thereby reducing the number of species described by previous workers. In his description of the genus *Tachygonetria* Seurat gives a table of the species described by him, and mentions in that table several new species; in the descriptive part, however, he omits to describe three new species mentioned in his table. From the tabular account I find that several of them are simply synonyms of the older species described, and are mentioned as such in the following account.

Although we possess a very useful account to serve as the basis of work, these accounts are hardly adequate, and in certain respects inaccurate and misleading. I therefore determined, at the suggestion of Professor R. T. Leiper, F.R.S., to work out more thoroughly than has hitherto been done the general morphology of the Oxyurids of Reptiles. I have tried to give as detailed an account as is possible of 22 species belonging to seven genera, distributed among three families. While studying the known forms available I have found some new species, three of which I am describing under two new genera, Alæuris and Veversia. These forms are interesting as they indicate relationships connecting together the various genera from reptiles.

I may here add that I am deeply indebted to Professor Leiper for the keen interest he has taken in my work. He has made many helpful suggestions and criticism, and allowed me the use of his private literature files. He also helped me by lending his drawings of the type species of *Tachygonetria* and *Thelandros* drawn from the type materials in the Vienna Museum. My grateful acknowledgments are also due to the members of the Institute of Agricultural Parasitology for their advice and suggestions in the course of my work.

Characters of Systematic Importance.

Seurat in the course of his descriptions lays special stress on the presence or absence of an accessory piece to distinguish the genera of *Tachygonetria* and *Thelandros*. In the course of my investigation I found that this character is not of much value in that in *Tachygonetria dentata* and some

other forms the accessory piece is sometimes absent amongst the members of the same species. Recollecting that the accessory piece is only a local thickening of the cloacal wall it may or may not be developed. Variations in the presence or absence of the accessory piece are met with also in the members of other genera belonging to different groups. Hence this alone could not be regarded as of generic value.

Length of the œsophagus is another character which was relied upon by Seurat as of generic value. He (1912) diagnosed *Tachygonetria* and *Thelandros* as follows:—" ces Oxyures se distinguent, en effet, non seulement par leurs dimensions (5 à 9 mm. pour l'un, 1·5 à 2·5 mm. pour l'autre), mais par une différence très appréciable dans la grandeur relative de l'œsophage: chez la *Thelandros alatus*, l'œsophagus est très court, sa lóngueur étant environ la sixième de la longueur totale; chez la *Tachygonetria vivipara*, au contraire, la longueur de l'œsophage est le tiers de la longueur totale." These characters alone as we shall see in the following descriptions cannot be regarded as of generic value. In the genus *Tachygonetria* we find variations in the length of the œsophagus in different species; thus in *T. longicollis* and *T. vivipara* the length is $\frac{1}{3}$ of the total body length, while in *T. uncinata* it is $\frac{1}{5}$ of the total length, so that the relative length of the œsophagus to the body cannot be considered to be of generic value. Further the œsophagus is highly contractile and may be of different length in different individuals depending upon the condition in which it was at the time of fixation.

On a closer examination of the various specimens from different hosts I found that the important difference of any value to be recognised as of generic value was the characters of the genital papillæ. In some the papillæ are pedunculated while in others they are sessile. This was further confirmed by a comparison with the drawings made by Professor Leiper from the original materials of the genera *Tachygonetria* and *Thelandros* from the Vienna Museum and the conclusion arrived at that the papillæ in the genus *Thelandros* are pedunculated while in *Tachygonetria* they are sessile. This character is fairly significant and agrees with the generic differences found also in the other families of Nematodes, like *Filariidæ* Claus.

The relative position of the female genital aperture to the middle of the body length also seems to be of generic value.

Besides these there are a few other characters, *e.g.*, the presence or absence of the caudal and lateral alæ, coupled with any of the above-mentioned characters, that may also be regarded as of generic value.

The following is a list of species described in the present communication :—

Family. Oxyuridæ Cobbold, 1864.
Genus Tachygonetria Wedl, 1862.
Species 1. T. vivipara Wedl, 1862 from Uromastix acanthurus.
2. T. conica (Drasche, 1883), Seurat, 1918, from Testudo ibera.
3. T. longicollis (Schneider, 1866), from Testudo ibera.
4. T. microlaimus (Linstow, 1899), from Testudo ibera.
5. T. macrolaimus (Linstow, 1899), from Testudo ibera.
6. T. dentata (Drasche, 1883), from Testudo ibera.
7. T. pusilla Seurat, 1918 from Testudo ibera.
8. T. microstoma (Drasche, 1883), from Testudo ibera.
9. T. uncinata (Drasche, 1883), from Testudo ibera.
10. T. stylosa sp. nov., from Testudo ibera.
Genus Veversia, gen. nov.
Species 11. V. tuberculata (Linst., 1904), from Tachysaurus rugosus.
Genus Alæuris, gen. nov.
Species 12. Alæuris alæuris, sp. n. from Testudo ibera.
13. A. iguanæ sp. nov., from Iguana tuberculata.
Genus Thelandros Wedl, 1862.
Species 14. Th. alatus Wedl, 1862, from Uromastix hardwickii.
Genus Pharyngodon Diesing, 1860.
Species 15. Ph. hindlei, sp. nov., from Tiliqua senicordis.
16. Pharyngodon sp., from Egernia cunninghami.
Genus doubtful (only females known).
Species 17. Oxyuris sp., from Testudo ibera.
18. Oxyuris sp., from Tachysaurus rugosus.
Family II. Atractidæ Travassos, 1920.
Genus Atractis Duj., 1845.
Species 19. Atr. dactyluris (Rud., 1819), from Testudo tabulata.
20. Atr. ortleppi, sp. nov., from Podocnemis unifilis.
Family Labiduridæ. Fam. nov.
Genus Labiduris Schn., 1866.
Species 21. L. gulosa (Rud., 1819), Schn., 1866, from Testudo tabulata.
22. L. zschokkei Linst., 1899, from Testudo tabulata.

Materials and Methods.

The material on which the present communication is based was collected on various occasions from the animals that died at the Gardens of the Zoological Society of London during the years 1922-25. Besides

this material there were several specimens received by Professor R. T. Leiper from other sources which were all placed at my disposal. The names of the hosts from which the parasites were collected are as follows :—*Iguana tuberculata, Uromastix acanthura, Uromastix hardwickii, Egernia cunninghami, Tachysaurus rugosus, Testudo ibera, Testudo tabulata, Podocnemis unifilis, Tiliqua senicordis.*

Various methods were employed for the examination of these worms and it was found that the following gave excellent results. Creosote and Lacto-phenol are excellent clearing reagents for larger Nematodes but for Oxyurids and other smaller forms they cannot be so usefully employed. These small worms become so transparent in these reagents that it is rather difficult to determine their exact morphology. It was found that the clearing in a mixture of Alcohol and Glycerine gave good results. The process is slow as it requires the evaporation of alcohol and thereby gradual penetration of glycerine into the worm. The specimens were examined in the remaining fluid.

Family Oxyuridæ Cobb, 1864.

Genus 1.—Tachygonetria Wedl, 1862.

Oxyurids of small size ; simple or bilobed lips ; no lateral or caudal alæ ; vulva behind the middle of the body ; ovejector present ; two uteri connected to the ovejector by a reservoir for eggs ; spicule single ; accessory piece present ; genital papillæ sessile.

Type species. *T. vivipara* Wedl, 1862, from *Uromastix spinipes.*

Tachygonetria vivipara Wedl, 1862.

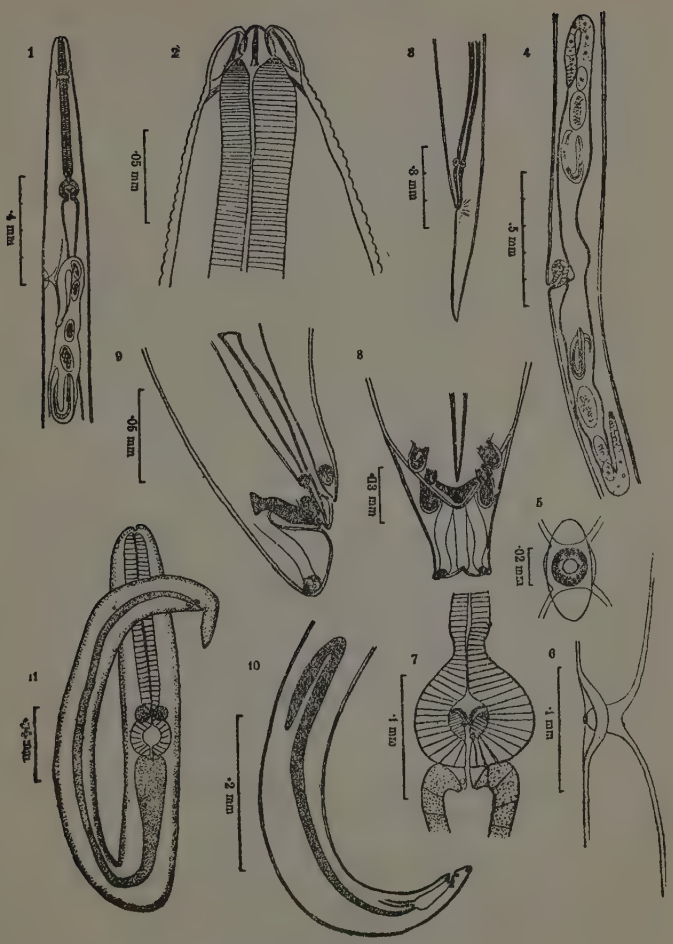
(Figs. 1-11.)

Syn. *Tachygonetria jugurthæ* Seurat, 1918.

The body is slender and of small size about 2-3 mm. long and gradually narrowing towards the extremities. Females are larger than the males which are rare.

The cuticle is thick, transversely striated, the striations being 6μ apart.

The lateral lines well developed and consist of a single row of large rectangular cells with distinct nuclei. Excretory pore lies behind the



Tachygonetria vivipara.

Fig. 1.—Anterior end of the female, lateral view.
Fig. 2.—Head end, ventral view. Fig. 3.—Female tail. Fig. 4.—Female genitalia.
Figs. 5 and 6.—Excretory pore and its connections : 5, ventral view ; 6, lateral.
Fig. 7.—Œsophageal bulb showing internal armature.
Fig. 8.—Posterior end, male, ventral view, showing papillæ, accessory piece and the end of the spicule. Fig. 9.—Same, lateral view.
Fig. 10.—Male genitalia. Fig. 11.—Embryo from the uterus.

bulb in both sexes. Just behind the bulb of the œsophagus, about ·9 mm. from the anterior end, is an oval cuticular depression on the ventral surface; in the centre of this depression is a spherical opening strengthened by a thick chitinous rim (Figs. 5 and 6). This is the excretory pore and it leads into a large spherical excretory vesicle joined to four excretory canals arranged in the form of X, two running forwards and two backwards. As the excretory canals proceed away from the excretory vesicle they become lost in the lateral area.

The head is distinctly marked off from the body and the mouth is surrounded by three semicircular lips bearing the cephalic papillæ. The buccal capsule is very short. The œsophagus is long, about $\frac{1}{3}$ of the total body length, and is ·48 mm. in the male and ·58 mm. in the female in length. It is lined internally by the thick cuticle and is connected to a large muscular bulb by a short narrow neck. The bulb is spherical and is provided with three strongly cuticularised grinding blades that strike against transversely striated chitinous scales found on the wall of the bulb. The bulb thus serves apparently as a masticatory organ. Posteriorly the bulb is produced into three flattened leaf-like œsophageo-intestinal valves projecting into the lumen of the chyle intestine. The intestine is rectilinear and is swollen at its origin into a pear-shaped enlargement smaller than the bulb. The rectum is short, about 169μ long, and is lined with thick cuticle. Its junction with the chyle intestine is marked by the presence of three unicellular rectal gland cells. The anus opens 160μ in front of the tip of the tail.

The nerve ring surrounds the œsophagus in its first quarter, and is ·15 mm. from the anterior end of the body.

The females are about 3 mm. long, with thick body, more or less straight, ending in an elongated tail about 428μ long.

The vulva is situated behind the middle of the body at a distance of 1·4 mm. from the tip of the tail. In order to understand the exact nature of the female genitalia some very young specimens were examined in which the genital organs had just developed. In a young individual the vulva is found leading into an elongated arched vagina curving backwards and ending in a muscular spherical ovejector. This is joined to two forwardly directed uteri by a short common duct corresponding

to the reservoir. The ovaries are large club-shaped massive structures full of dense protoplasm, and in the distal part each contains a small immature ovum. They are opposed. As the animal grows and the embryos become developed within the uterus the two limbs of the uteri are pushed in opposite directions and elongate owing to the great development of the large number of embryos, so that in a fully developed female the uteri are divergent and there is no common reservoir. The free ends of the ovaries are directed towards each other.

The embryo (Fig. 11) is ·41 mm. long and is coiled on itself. It has its alimentary canal fully developed as in the adult, and in front of the œsophageal bulb are found a pair of spherical cells full of fine granular materials. The armature of the bulb is not yet developed and the nerve ring is not visible at this stage.

In certain specimens the eggs are also found and the embryos are not developed. The eggs in these oviparous forms vary in size according to the condition of their development. Their average measurement is 170μ by 52μ.

The male is only 1·65 mm. long and has a maximum diameter of 90μ. The posterior end of the body narrows down and behind the cloaca on the ventral side it is abruptly cut by a deep cleft. The tail is truncated and rounded at the extremity. Looked at from the ventral side it is trapezoidal in outline about 36μ long, and bears a pair of lateral papillæ at the truncated extremity; besides these there are also three pairs of cloacal papillæ that are sessile. The pre-anal and the post-anal pairs are large and the adanal pair is small, and in some specimens is liable to degenerate and disappear.

The posterior lip of the cloaca is conical and protrudes while the anterior lip is pointed.

There is a single spicule, acicular, slightly swollen near the proximal end, and gradually tapering to the extremity. Its length varies from 100μ to 130μ. The accessory piece is in the form of a wide V about 36μ long.

The genital organs of the male are very simple, and consist of an elongated tube bent on itself. The first part forms the narrow testis which curves back and dilates into a wider tube, finally opening at the cloaca by a narrow duct. The spermatozoa are spherical and have no processes.

Lying above the cloaca, between it and the body wall, is a pair of large pear-shaped caudal glands each leading by a wide duct to the base of the caudal papillæ, where they seem to open. They are said to secrete a chitinous material round the female aperture at the time of coition.

Habitat.—Cæcum of *Uromastix acanthinurus* and *Iguana tuberculata*.

Remarks.—Seurat (1918) mentions in his table of the species of *Tachygonetria* a new species, *T. jugurthæ*, which is distinguished by him from *T. vivipara* by the greater length of its œsophagus and the massive size of the female. He does not give any further description of his new species. These characters do not appear to the writer to be of any great importance, as the thickness of the female in *T. vivipara* depends upon the number of embryos found within the uterus, and the œsophagus is very contractile and may vary according to the state in which they are fixed. Hence I regard these two names as synonyms.

2.—Tachygonetria conica (Drasche, 1883), Seurat, 1918.

Synon. *Oxyuris conica* Drasche, 1883.

Body is stout, gradually narrowing towards the extremities. Males are 1·75 mm. long and females 3 mm. long.

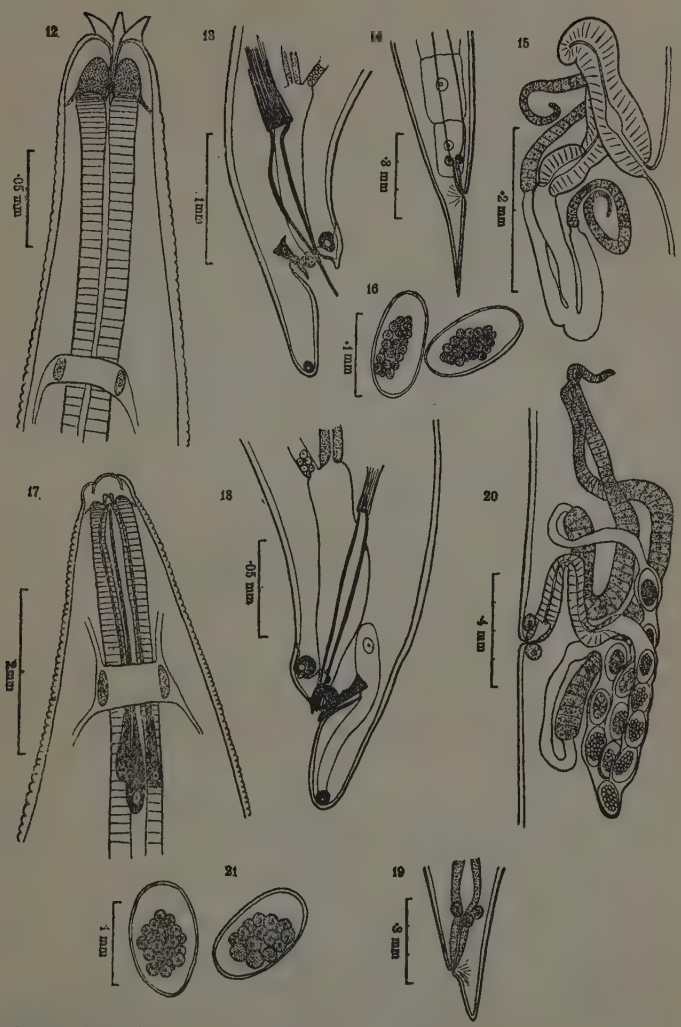
The cuticle is transversely striated, the striations not being very marked at the anterior end.

There are three lips each bearing a conical hyaline projection in front; buccal cavity, short; œsophagus is long connected by a short neck posteriorly to the bulb which is provided with chitinous blades; its total length, including the bulb, is ·91 mm. in male and 1·15 mm. in female. The anterior swelling of the intestine is larger than the bulb.

The nerve ring surrounds the anterior fifth of the œsophagus, and is 85μ in the male and 188μ in the female from the anterior end of the body.

The excretory pore is about 1·11 mm. from the anterior end in both the sexes.

The female attains its maximum thickness of 200μ at about the level of the bulb. Posteriorly the body forms a narrow elongated conical tail ·35 mm. long. The vulva is behind the middle of the body, being ·95 to 1·1 mm. from the tip of the tail. The vagina is short, ·1 mm. long,



Tachygonetria conica.

Fig. 12.—Head end greatly enlarged, ventral view.
Fig. 13.—Posterior end of male, lateral view.
Fig. 14.—Female tail, lateral view.
Fig. 15.—Female genitalia. Fig. 16.—Eggs.

Tachygonetria longicollis.

Fig. 17.—Head end, greatly enlarged, dorsal view. Note the buccal glands.
Fig. 18.—Posterior end of male, lateral view.
Fig. 19.—Female tail, lateral view. Fig. 20.—Female genitalia. Fig. 21.—Eggs.

and leads into an elongated ovejector bent backwards on itself to become connected to an oval bulb. A common reservoir arises from it; this divides posteriorly into two parallel uteri running forward on either side of the reservoir. The ovaries are elongated, tubular and full of eggs.

The eggs are large, 130μ by 60μ, with a double shell covering. They are in a fairly advanced stage of segmentation at the time of laying.

The male is rather stout, 1·75 mm. long and ·1 mm. thick. It is slightly curved on the ventral side of the body, terminates in a short trapezoidal tail 85μ long, and bearing a pair of sessile caudal papillæ. There are only two pairs of genital papillæ round the cloaca, the adanal pair being absent. The pre-anal pair is the largest. The posterior lip of the cloaca projects to form a conical nipple while the ventral lip is produced into a pointed process behind. The spicule is elongated and acicular with a distinct handle; it varies in length from 120μ to 140μ. The accessory piece is in the form of a broad stumpy V.

Habitat.—Cæcum of *Testudo ibera*.

Affinities.—This form resembles *T. vivipara*, but can be distinguished from it by the presence of the hyaline conical processes on the lips, parallel uteri, and the absence of the adanal pair of genital papillæ.

3.—Tachygonetria longicollis (Schn., 1866) Seurat, 1918.

Synon. *O. longicollis* Schn., 1866, in part; *Paracis longicollis* (Schn.) R. & H., 1916, in part; *T. massinissæ*, Seurat, 1918; *T. setosa*, Seurat, 1918.

Oxyurids of medium size, males usually rare and smaller than the females. The cuticle is thick and transversely striated; lateral areas formed of large rectangular cells; excretory pore 1·55 mm. in the female and ·86 mm. in the male from the anterior end of the body: *i.e.*, prebulbar in the female and postbulbar in the male.

Head distinct; mouth surrounded by three semi-circular lips; buccal cavity short; œsophagus narrow, elongated and highly contractile, connected by a narrow neck to the posterior bulb which is armed with chitinous blades; anteriorly, it is produced into three cuticular teeth and outside these into three hyaline lamellæ, each terminating in a rounded knob; all project into the buccal cavity.

There are three pairs of elongated pear-shaped gland cells surrounding the œsophagus. Each gland cell is finely granular in nature and contains an oval nucleus in its posterior broad portion ; it is produced forwards into a very long narrow duct which can be traced as far forward as the buccal cavity. From the disposition of the openings of these glands they are termed the buccal glands. I have already described the presence of these glands in the genus Echinopharynx under the heading " Organs of Problematic Nature," and hinted that they may be present in all nematodes. Their exact nature has not yet been ascertained, but it may be suggested from their position that they may secrete a fluid into the buccal cavity to act on the food material. The nerve ring surrounds the œsophagus ·18 mm. (male) and ·265 mm. (female) from the anterior end, *i.e.*, its position divides the œsophagus in the ratio of 1 : 5. The intestine is swollen at its commencement into a pear-shaped enlargement and the rectum is short, being about 180μ long.

The female is about 5 mm. long and has the maximum diameter of 350μ. The tail is short, thick and conical, about ·14 to ·18 mm. in length.

The vulva is situated behind the middle of the body, about 1·67 mm. from the tip of the tail ; the vagina is 80μ long and is forwardly directed ; the ovejector is long, curves back to join the elongated reservoir full of eggs ; there are two parallel uteri running forward and curving back to be connected to the corresponding ovaries by a short narrow oviduct ; the ovaries are large, massive and club-shaped, passing forward as far as the excretory pore.

The eggs are large, 140μ by 85μ, and are in a fairly advanced stage of segmentation at the time of laying. Segmentation begins while they are descending the uterus.

The male is 2·75 to 3 mm. long, with a maximum diameter of 150μ ; the body is curved ventrally into a small arc ; the tail is trapezoidal and bears at its termination a pair of lateral caudal papillæ ; ventrally, behind the cloaca, the body is deeply excavated by a cleft. There are only two pairs of papillæ round the cloaca, the adanal pair being absent. In certain specimens the position of the absent adanal papillæ is indicated by the presence of an irregular granular mass between the other two cloacal papillæ.

The spicule is slender, acicular, pointed distally and rounded at the head end ; it is 100μ to 120μ long. The accessory piece 30μ long, and the caudal glands are similar to those found in the type specimens.

The genitalia of the male are of the usual type, consisting of a single tube bent on itself and opening into the cloaca ventral to the gut.

Habitat.—Cæcum of *Testudo ibera*.

Affinities.—This species originally described by Schneider (1866) was later re-discovered by Drasche (1883). Both have given brief descriptions and figured the posterior end of the male. Both from their description and the figure the writer finds that the spicule is simple, having no outgrowth arising from it. Seurat (1918) describes the spicule in *longicollis* as possessing a pair of lateral barbels somewhat similar to that found in *T. pusilla*. In the same communication, however, he has described a new species, *T. massinissæ*, which resembles in description the present one. I, therefore, consider that *T. massinissæ* is a synonym of *T. longicollis*. Another species described by Seurat as *T. setosa* differs from *T. longicollis* only in having the body of the female thickly covered with long hairs ; in all other respects, and in male characters, it is identical with *T. longicollis*. Hence I regard *T. setosa* also as a synonym of *T. longicollis*, and that the females in this species are dimorphic.

T. longicollis resembles *T. conica* in the absence of adanal papillæ and in the female genitalia ; it however can easily be distinguished from the latter by the presence of teeth and clear leaf-like protuberances from the anterior end of the œsophagus, the position of the excretory pore, character of the spicule, absence of the hyaline processes of the lips and the relative length of the female tail.

4.—Tachygonetria microlaimus (Linst., 1899), Seurat, 1918.

Synon. *Oxyuris microlaimus*. Linst., 1899.

The body is stout and straight in the female, slightly arched on the ventral side in the male. The cuticle is thick and transversely striated. The excretory pore is 1·42 mm. (female) and ·88 mm. (male) from the anterior end, *i.e.*, it is situated at about the level of the posterior bulb of the œsophagus.

The head is distinctly marked off and the mouth is surrounded by three semi-circular lips.

The œsophagus is long and narrow, and is connected to the posterior bulb by a short narrow neck ; it is about $\frac{1}{3}$ the total length of the body, being ·87 mm. long in the male and 1·43 mm. long in the female. Anteriorly it bears three triangular lamellar projections. The bulb is slightly elongated and provided with chitinous blades of the usual type. Intestinal swelling at the anterior end is slightly larger than the bulb. The rectum is short, 120μ long ; rectal gland cells are present. The nerve ring surrounds the œsophagus in its anterior quarter and is 190μ (male) and 230μ (female) from the anterior end of the body.

The female is 3 mm. long with a maximum diameter of 420μ ; the body tapers posteriorly to form a slender tail, 170μ long. The vulva is situated behind the middle of the body about 1·2 mm. from the tip of the tail. The vagina is short and forwardly directed ; the ovejector is long and tubular with thick muscular walls ; it is bent back on itself crosswise and leads into a long wide reservoir bifurcated posteriorly to join the two uteri which pass forwards on either side of it ; the ovaries are short, slender and club-shaped.

The eggs are large, 115μ by 80μ, with double shell ; segmentation begins while they are still in the uterus.

The male is 2·25 mm. long, the body is deeply excavated behind the cloaca ; it is slightly arched. The tail is short and trapezoidal, bearing a fine dorsal mucron about 10μ long. There are two pairs of caudal papillæ, one pair large and lateral in position while the other is small and is situated at the point of insertion of the mucron ; the caudal glands appear to open at the base of the smaller pair. There are three pairs of papillæ round the cloaca, the adanal pair being the smallest.

The spicule is stout and is about 100μ long ; it consists of an acicular shaft and a handle. The accessory piece, in the form of a wide V, is 30μ long.

Habitat.—Cæcum of *Testudo ibera*.

Affinities.—This form resembles *T. longicollis* and *T. conica* from which species it can easily be distinguished by the presence of a dorsal mucron on the tail of the male, by the larger number of papillæ and by the shape of the spicule. It differs from *T. longicollis* also in the absence of teeth at the anterior end of the œsophagus. The shape and character of the spicule resembles that of *T. conica* from which species it differs by the absence of hyaline triangular processes on the lips.

5.—Tachygonetria macrolaimus (Linst., 1899), Seurat, 1918.

Synon. *Oxyuris macrolaimus* Linst., 1899.

These are small sized worms, straight in the female, arched ventrally in the male, and tapering towards the extremities.

The cuticle is thick and transversely striated; the lateral areas are well marked as in the other species. The excretory pore is situated at the level of the bulb in the female and a little behind it in the male; it is 545μ (male) and 640μ (female) from the anterior end.

The head is not distinct; the mouth is surrounded by three bilobed lips each lobe being provided with a cephalic papilla. There is no buccal cavity; the mouth leads into a short pharynx continued back into an elongated œsophagus about $\frac{1}{3}$ the total body length. The œsophagus is ·49 mm. long in the male and · 66 mm. in the female and is connected posteriorly by a short neck to a spherical bulb armed with three grinding blades. Anteriorly the intestine is swollen to form a pear-shaped enlargement a little smaller than the bulb. The rectum is short being 135μ long. The anus is situated ·51 mm. from the tip of the tail.

The nerve ring surrounds the anterior quarter of the œsophagus at 134μ (male) and 175μ (female) from the anterior end.

The female is slender and 2·75 mm. long with a maximum diameter of 182μ. Posteriorly, behind the anus, the body gradually tapers to form a narrow and comparatively long tail about 510μ in length.

The vulva is situated behind the middle of the body about 1·16 mm. from the tip of the tail; the vagina is club-shaped, forwardly directed and joins the ovejector which recurves on itself, the latter forms a spherical swelling and then joins the two opposed uteri; the posterior uterus eventually curves forwards to join its ovary, while the anterior uterus first curves backwards and then forwards again to join its forwardly running ovary. The ovaries are large club-shaped structures running parallel to each other, and extending forward as far as the posterior limit of the œsophageal bulb.

The eggs are few in number and measure 100μ by 60μ; segmentation proceeds while they are still in the uterus.

The male body is thin, 1·9 mm. long with a maximum diameter of 180μ. The tail is elongated and trapezoidal and is terminated by an elongated mucron 25μ long. This mucron is not mentioned by von Linstow in his description nor is it shown in his figures. There are three pairs of papillæ round the cloaca, the adanal pair as usual being the smallest of the series. The caudal papillæ are large being about the size of the pre-anal papilla.

The spicule is elongated, acicular and about 60μ long, the head end being separated by a slight constriction. Accessory piece is of the usual type, about 24μ in length.

Habitat.—Cæcum of *Testudo ibera*.

Affinities.—The presence of three pairs of circumcloacal papillæ, the presence of the mucron on the tail of male and the bulb at the commencement of the ovejector allies this species to *T. microlaimus*. It can, however, be readily distinguished from the latter by its bilobed lips, by its long tail, by the absence of the genital reservoir in the female, by the replacement of hyaline lamellæ of the œsophagus by a pharynx, and by the large caudal papillæ.

6.—Tachygonetria dentata (Drasche, 1883) Seurat, 1918.

Synon. *Oxyuris dentata* Drasche, 1883.

The body is stout, straight in females, slightly bent ventrally in the male.

The cuticle is thick and transversely striated. The lateral area as in the type species; excretory pore is behind the bulb in both sexes and is ·53 mm. (male) and 1·01 mm. (female) from the anterior end of the body, as usual it lies in an oval cuticular depression on the ventral side.

The head is not distinctly marked off from the body; the mouth is surrounded by three deeply bilobed lips, which are slightly raised; each lobe bears a cephalic papilla; a buccal cavity is absent.

The œsophagus is short, tubular, slightly dilated anteriorly and is terminated posteriorly in a pear-shaped bulb armed with fine teeth and grinding blades. Its length including the bulb is ·392 mm. in male and ·575 mm. in female. The œsophageo-intestinal valves are small and

broad. Drasche (1883) mentions the presence of a row of fine teeth at the anterior end guarding the entrance to the œsophagus. I have not been able to see these teeth and Seurat (1918) also does not mention them.

The intestine is swollen into a small enlargement at its anterior end; the rectum is short, about 292μ long, and the anus is situated at a distance of 250μ from the tip of the tail.

The nerve ring is found in the anterior third of the œsophagus, 116μ to 120μ (male) and 170μ (female) from the anterior end. There are large ganglion cells each with a large oval nucleus.

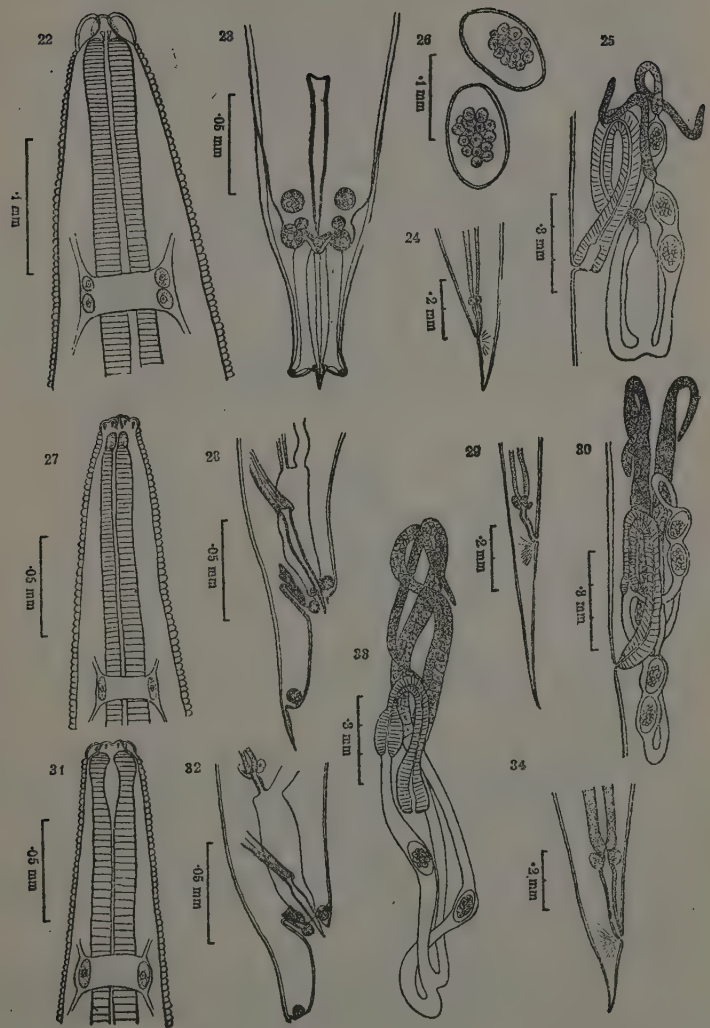
The female body is stout, fusiform, straight and 4 to 5 mm. long, with a maximum diameter of 360μ at about the middle of its body. The tail is short, conical and about 250μ long.

The vulva does not protrude; it is situated at about the middle of the body or a little behind it; the vaginà is short and passes forwards into a long ovejector folded back and terminating in an oval muscular bulb; the reservoir is long and narrow and divides at its posterior end into two uteri running forwards. Each ovary is a large massive organ occupying the space between the vulva and the excretory pore.

The eggs are large and vary in number in different individuals; they have a double shell-covering, are about 135μ long and 60μ broad, and segment as they descend the uterus.

The male is slender, straight and much smaller than the female; it is about 1·70 mm. long, with a maximum diameter of 110μ. The cuticle is distinctly striated and naked. Seurat (1918) mentions that the cuticle is covered with long hairs, which I have not been able to see. The tail is of the usual type and bears at its extremity a very short dorsal, hyaline mucron.

Tachygonetria microlaimus. Fig. 22.—Head end, greatly enlarged, ventral view. Fig. 23.—Posterior end of male, ventral view.
Fig. 24.—Female tail, lateral view. Fig. 25.—Female genitalia. Fig. 26.—Eggs.
Tachygonetria macrolaimus. Fig. 27.—Head end, ventral view.
Fig. 28.—Posterior end of male, lateral view.
Fig. 29.—Female tail, lateral view. Fig. 30.—Female genitalia.
Tachygonetria dentata. Fig. 31.—Head end, dorsal view.
Fig. 32.—Posterior end of male, lateral view.
Fig. 33.—Female genitalia. Fig. 34.—Female tail, lateral view.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There is a pair of large caudal papillæ at the tip of the tail and two pairs of papillæ round the cloaca ; the adanal pair is absent.

The spicule is very short, about 38μ long, it is acicular and has a rounded tip. An accessory piece is sometimes present and sometimes absent ; when present it is of the usual form and about 15μ long.

The anterior lip of the cloaca bears a pointed protuberance behind.

Habitat.—Cæcum of *Testudo ibera*.

Affinities.—This species resembles *T. macrolaimus* in its large size, bilobed lips, post-bulbar position of the excretory pore and the presence of a dorsal hyaline mucron on the tail of the male ; it can, however, be easily distinguished from *T. microlaimus* by its six noduliform lips, its short œsophagus, the absence of prepharynx, the presence of teeth in the bulb, the oval bulb of the ovejector, the presence of a reservoir, the size of the spicule and the number of the genital papillæ in male.

7.—Tachygonetria pusilla Seurat, 1918.

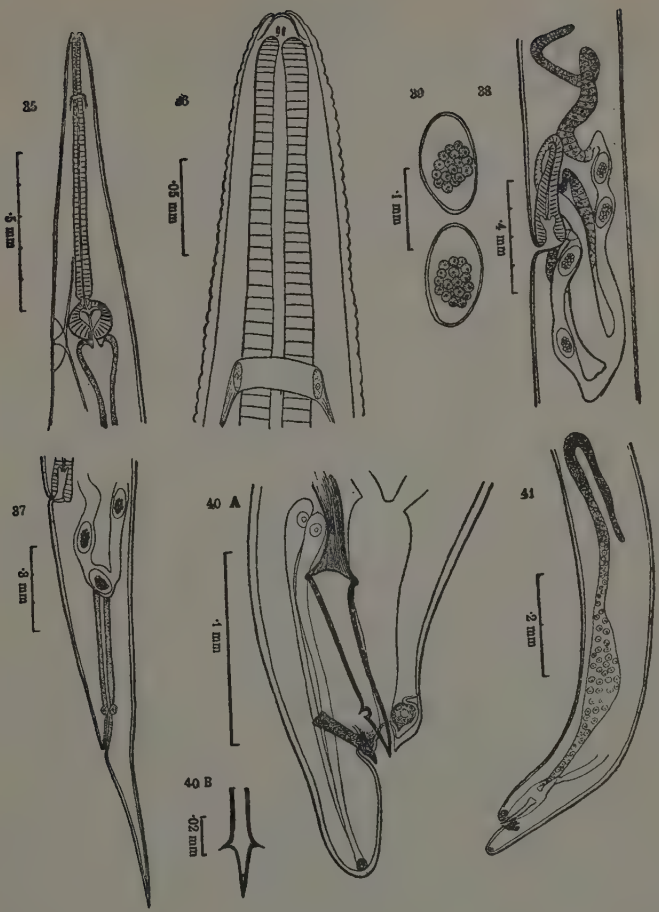
Synon. *Oxyuris longicollis*, Schn., 1866, in part.
Paracis longicollis (Schn., 1866), Raill. and Henry, 1916, in part.

The body is thick, stout and of small size, straight in female, slightly curved ventralwards in the male. Length of the male 1·75 mm., of the female 3·25 mm.

The cuticle is thick and transversely striated ; the lateral areas are well developed ; the excretory pore is situated at the level of the bulb in both sexes, being 665μ (male) and 980μ (female) from the anterior end of the body ; it lies in an oval cuticular depression on the ventral side.

The head is not distinct ; the mouth is surrounded by three simple, broad and conical lips, slightly rounded at their apices. The buccal cavity is very short and narrow.

The œsophagus is narrow and elongated, and is connected by a short narrow neck to its posterior bulb, which is spherical and armed with chitinous blades ; its length is about ·65 mm. in male and ·97 mm. in female. The œsophageo-intestinal valves are triangular and elongated



Tachygonetria pusilla.

Fig. 35.—Anterior end of body, showing general characters, lateral view.
Fig. 36.—Head end, greatly enlarged, dorsal view.
Fig. 37.—Posterior part of female, showing tail, anus and vulva, etc.
Fig. 38.—Female genitalia. Fig. 39.—Eggs.
Fig. 40A.—Posterior end, male, lateral view.
Fig. 40B.—End of spicule, showing lateral barbs. Fig. 41.—Male genitalia.

and project into the anterior funnel-shaped swelling of the chyle intestine. The rectum is short being about 160μ long; the anus is situated 560μ in front of the tip of the tail. Rectal gland cells are present in the usual position.

The nerve ring surrounds the œsophagus in its anterior quarter, about 50μ to 52μ (male) and 250μ (female) from the anterior end of the body; it possesses large ganglion cells with large nuclei.

The female body is stout, straight, and has a maximum thickness of 360μ; it is terminated posteriorly by an elongated awl-shaped tail, which is 560μ long.

The vulva does not protrude; it is situated behind the middle of the body about 1·49 mm. from the tip of the tail; the vagina is short and has two lateral pocket-like horns (bicornuate); the ovejector is long and is folded back on itself and joins an elongated and slightly swollen reservoir, which passes posteriorly; this reservoir divides into two uteri, which pass forwards parallel to each other, one on either side of it; the ovaries are large and massive, being packed with dense granular cells. The eggs are large and thick-walled, measuring 122μ by 70μ; segmentation sets in during their descent in the uterus.

The male is very small, slender, about 1·75 mm. long with a maximum diameter of 155μ. The tail is trapezoidal, more or less rounded at the extremity, and bears a pair of small caudal papillæ at the end. There are only two pairs of genital papillæ round the cloaca, there being no adanal pair; the pre-anal pair is large and terminates posteriorly in a small pointed process; the post-anal pair is slightly elongated.

The spicule is broad and stout with its head end dilated and gradually narrowing posteriorly; near its tip it bears a pair of lateral barbels, giving it the appearance of a sting. In some specimens there are two pairs of these barbels, one behind the other (Fig. 40A). The spicule is 90μ long. The accessory piece is large and stout being about half the size of the spicule; it is V-shape, 42μ long and possesses long limbs.

The caudal glands have elongated narrow ducts, which open at the base of the caudal papilla.

Habitat.—Cæcum of *Testudo ibera*.

Affinities.—This species resembles *T. longicollis* in general characters,

but can be easily distinguished from the latter by the character of its spicule, and the accessory piece in the male, by the peculiar awl-shaped tail of the female and by the bicornuate vagina.

8.—Tachygonetria microstoma (Drasche, 1883).

Synon. *Oxyuris microstoma* Drasche, 1883; *Oxyuris robusta* Drasche, 1883; *Oxyuris draschei* Stossich, 1898; *Tachygonetria weissi* Seurat, 1918; *Mehdiella microstoma* (Drasche, 1883), Seurat, 1918.

The body stout and of medium size, straight in the female and slightly bent in the male. The cuticle is thick and is transversely striated; lateral area composed of large cells in a single row; excretory pore ventral, prebulbar in the female and about 2·1 mm. from the anterior end, behind the bulb in the male being 1·93 mm. from the anterior extremity. It is strengthened by a cuticular hem and is connected to a large pear-shaped excretory vesicle. Arising from the vesicle are four excretory canals—two running forwards and two backwards in the lateral areas in which they become indistinguishable as they proceed away from the vesicle.

The head is not quite distinct; the mouth is surrounded by three prominent lips; buccal cavity is absent. The œsophagus is elongated and slightly dilated at its anterior end and is connected by a short neck to a large spherical bulb armed with strong curved chitinous blades. In the anterior wall of the posterior bulb there are a large number of fine conical spines or teeth, not noticed by any of the previous observers. The œsophageo-intestinal valves are triangular and project into the anterior funnel-shaped cavity of the chyle-intestine. The œsophagus, including the posterior bulb, is 1·02 mm. long in the male, and 2·35 mm. in the female. The rectum is short, being 300μ long; it is marked off from the intestine by the position of the rectal gland cells. The posterior end of the intestine is strengthened by the presence of strong cuticular thickening. The anus is ·56 mm. from the tip of the tail.

The nerve ring is very far forward and has large ganglion cells with oval nuclei. It surrounds the œsophagus ·28 mm. (male) and ·3 mm. (female) from the anterior end.

The female body is stout, about 7·2 mm. long, with a maximum diameter of 530μ. It terminates posteriorly in a long conical tail pointed at the end, and ·56 mm. in length.

The vulva is situated behind the middle of the body as in the other species, about 3·24 mm. from the tip of the tail ; the vagina is long and directed forwards, and possesses a wide cavity ; the ovejector is very long and curves backwards as far as the vulva and then divides into two divergent uteri containing eggs in various stages of development, up to the embryo stage (ovoviviparous). Each uterus folds back to join a narrow oviduct leading from the large, massive and club-shaped ovary.

The eggs are large, measuring 180μ by 80μ. The embryo has a well developed alimentary canal, provided with an armed œsophageal bulb and the intestine is composed of large cells. The anus is not yet formed and the nerve ring is not distinguishable. There is a short tail and the lateral areas are well-marked.

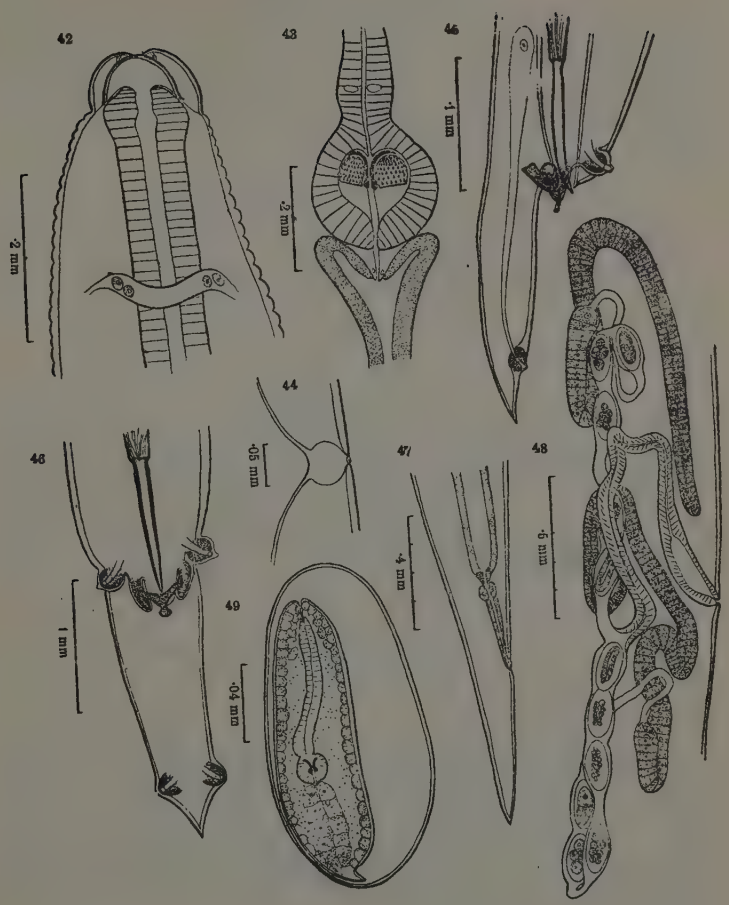
The male is smaller and thinner than the female, and is 5·5 mm. long with a maximum diameter of 200μ. The tail, 182μ long, terminates in a small dorsal point.

The caudal papillæ lie a little in front of the tip of the tail. There are only two pairs of genital papillæ surrounding the cloaca—a large pre-anal and an elongated post-anal.

The caudal glands are of the usual type, and have the usual disposition. The spicule is elongated, acicular with a flattened head end, and is 95μ to 100μ long. The accessory piece is in the form of a wide V ; it is 40μ to 45μ long and bears a rounded knob at the posterior end.

Habitat.—Cæcum of *Testudo ibera*.

Affinities.—Seurat (1918) created a new genus—*Mehdiella*—for the reception of this species, and also assigned another species, *M. uncinata*, to it. As already quoted from Seurat, the only difference indicated by him between *Tachygonetria* and *Mehdiella* is in the nature of the caudal point in the male ; this character has been shown to be present in some of the species described by Seurat under the genus *Tachygonetria*. Further, the general morphology of this form is based on characters similar to those exhibited by Tachygonetria. The writer, therefore, considers the genus Mehdiella to be a synonym of Tachygonetria and the species described



Tachygonetria microstoma.

Fig. 42.—Head end, dorsal view.

Fig. 43.—Œsophageal bulb, showing internal armature.

Fig. 44.—Excretory pore and its connections.

Fig. 45.—Posterior end, male, lateral view. Fig. 46.—Same, ventral view.

Fig. 47.—Female tail, lateral view. Fig. 48.—Female genitalia.

Fig. 49.—Embryo from the uterus, within the egg-shell.

by Seurat under his new genus are brought back to the older genus Tachygonetria. Seurat also described a new species, *Tachygonetria weissi*, whose description coincides with the present form ; it is, therefore, considered to be the same. The present species can easily be distinguished from all others by its size, by the presence of spines in the posterior bulb, and by the shape of the accessory piece.

9.—Tachygonetria uncinata (Drasche, 1883).

Synon. *Oxyuris uncinata* Drasche, 1883 ; *Oxyuris inflata* Drasche, 1883 ; *Mehdiella uncinata* (Drasche, 1883) Seurat, 1918.

The body is stout, thick and rather long, straight in the female, curved ventrally in the male.

The cuticle is thick, with transverse striations and is detached from the body wall in the cephalic region, forming several vesicular swellings. Of these swellings the second is the largest in the female, while in the male there are first three swellings of equal size and larger than the following ones on the body, which are marked by the usual transverse striations. The lateral areas are well developed and the excretory pore is situated behind the bulb in both sexes—·78 mm. (male) and 1·49 mm. (female) from the anterior end of the body.

The head is distinctly marked off, and the mouth is surrounded by three lips deeply bilobed, each lobe being provided with a cephalic papilla ; there is no buccal cavity.

The œsophagus is short, about ·66 mm. long in male and 1·3 mm. in female ; it is armed with chitinous blades of the usual type in its bulb, to which it is connected by a short neck ; the œsophageo-intestinal valves are of the usual type ; the intestine is funnel-shaped at its origin and rectilinear behind ; the rectum is short, 280μ long, and bears the usual rectal gland cells at its commencement.

The nerve ring, with large ganglion cells, surrounds the œsophagus in its anterior third, about 195μ in male and 295μ in female from the anterior end of the body.

The female body is fusiform, 5 mm. long, with a maximum thickness of 470μ at the middle of the body ; the tail is short and conical and is

continuous with the dorsal body wall. In some specimens it is surrounded by a sheath of dark-coloured material, probably secreted by the caudal glands.

The vulva is situated behind the middle of the body, about 2·25 mm. from the tip of the tail ; the vagina is short and is directed forwards ; the ovejector is long and is folded on itself ; it leads into an elongated reservoir which divides into two forwardly running uteri ; the ovaries are massive and club-shaped and extend forwards as far as the excretory pore.

The eggs measure 143μ by 78μ, and are laid in an advanced stage of segmentation.

The male is smaller than the female and is 3 mm. long with a maximum diameter of 220μ. The cephalic swellings are not so large as in the female and are all of the same dimensions. The tail is bent up dorsally into an elongated point and bears a pair of caudal papillæ in the posterior third of its length. There are three pairs of genital papillæ surrounding the cloaca, the adanal being the smallest.

The spicule is long, acicular, 75μ in length, and is swollen at about its middle. The accessory piece, 23μ long, is of the usual type, and so are the caudal glands.

Habitat. Cæcum of *Testudo ibera.*

Affinities.—Drasche (1883) mentions that there are eight lips, but the writer agrees with Seurat that there are only three lips deeply bilobed. The genital papillæ are not as in *T. longicollis* ; here there are three pairs of circum-anal papillæ. According to Seurat (1918) the first cephalic swelling is the largest in this species thus giving the head a globular appearance. Drasche (1883) mentions and figures the second swelling as the largest and is preceded by a small swelling. In this character I agree with Drasche. Probably it may be a variable character. Further, Seurat describes the presence of thick woolly hairs covering the body of the female. I have not been able to find any trace of them in any of the specimens examined.

This species resembles *T. microlaimus* in possessing three pairs of genital papillæ surrounding the cloaca but differs from it in having deeply bilobed lips, no hyaline lamellæ in front of the œsophagus, post-bulbar

excretory pore, and cephalic ornamentations. It resembles *T. microstoma* in the character of the male tail, but can be easily recognised from it by its parallel uteri, absence of spines in the œsophageal bulb, shape of the accessory piece and peculiar ornamentation of its head. In this last character it differs from all other species of the genus.

10.—Tachygonetria stylosa sp. nov.

The body is small, slender, straight in the female, slightly curved on the ventral side in the male.

The cuticle is thick, distinctly striated. The body wall is compressed a little behind the head, thereby giving it the appearance of a cuticular collar round the anterior end; the lateral areas are well developed and have a single row of large cells; the excretory pore is at the level of the bulb in the female, and behind it in the male and is 1·35 mm. in the former and ·88 mm. in the latter from the anterior end of the body.

The head is distinct; the mouth is surrounded by three simple lips each bearing two styliform processes in front; the buccal cavity is short.

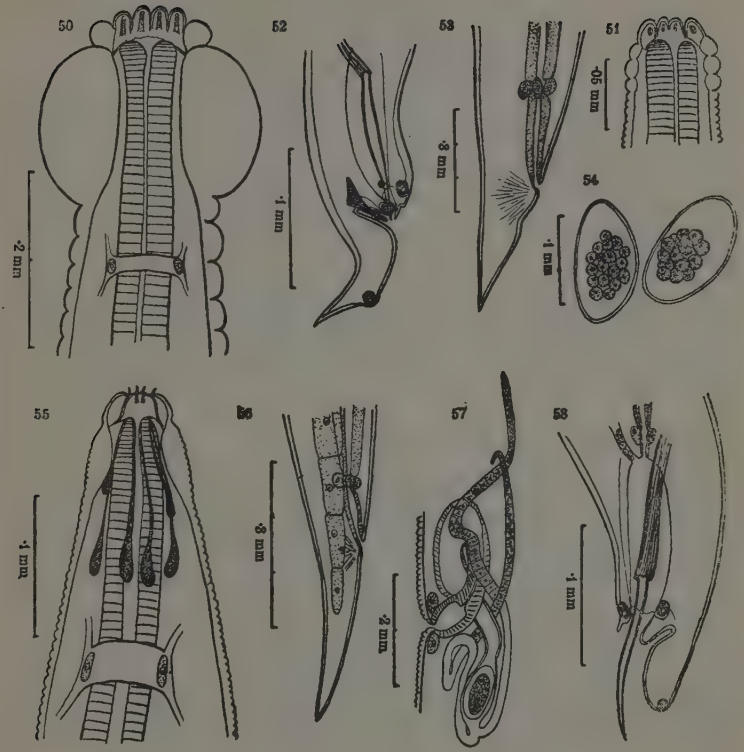
The œsophagus is long and is connected by a short neck to the posterior bulb armed with chitinous blades. It is 1·15 mm. long in the female and ·77 mm. in the male. Œsophageo-intestinal valves are of the common type projecting into the chyle-intestine.

Three pairs of buccal glands surround the œsophagus, of these, two pairs are large and one pair is small. They open into the buccal cavity.

The intestine is rectilinear, forming a pear-shaped enlargement at its anterior end; the rectum is short, 120μ long, and opens 325μ from the tip of the tail.

The nerve ring surrounds the œsophagus in its anterior third, at 156μ in the male and 185μ in the female from the anterior end.

The female body is stout, 3·225 mm. long with a maximum diameter of 280μ; the tail, 325μ long, is slightly curved dorsally. The vulva is behind the middle of the body, about 1·35 mm. from the tip of the tail; the vagina is short, about 72μ long, and is surrounded towards its external opening by three large pear-shaped cells; the ovejector, long



Tachygonetria uncinata.

Fig. 50.—Head end, female, dorsal view. Fig. 51.—Head end, male, dorsal view.
Fig. 52.—Posterior end of male, lateral view.
Fig. 53.—Female tail, lateral view. Fig. 54.—Eggs.

Tachygonetria stylosa.

Fig. 55.—Head end, dorsal view. All six buccal glands are shown.
Fig. 56.—Female tail, lateral view. Fig. 57.—Female genitalia.
Fig. 58.—Posterior end, male, lateral view. Accessory piece omitted.

and muscular, curves back to join the elongated tubular reservoir; the two uteri are parallel and lie one on either side of the reservoir; the ovaries are large and club-shaped.

The eggs are large, 120μ by 62μ, and are segmented *in utero*.

The male, 1·89 mm. long, is slender, slightly curved ventrally, and has a maximum diameter of 180μ; its tail, about 60μ long, is rounded at the apex and bears at its extremity a pair of caudal papillæ; there are only two pairs of equal papillæ surrounding the cloaca, the adanal pair being absent. The ventral lip of the cloaca is prolonged into a spur-like process.

The spicule is slender, acicular, about 120μ long, with a flattened head. The accessory piece (which has unfortunately been omitted in the Fig. 58), is very small, about 20μ long, and is in the form of a wide V with short limbs.

Habitat.—Cæcum of *Testudo ibera*.

Affinities.—This species, in having a contracted body-wall shows an apparent cephalic swelling like that found in *T. uncinata* but on a closer examination the difference is at once recognised. It also differs from it in its styliform processes on the lips, in the absence of caudal point, in the shape of the spicule and the accessory piece, and in the number of the genital papillæ round the cloaca. In the absence of the caudal tip, the shape of the spicule and the genital papillæ, it resembles the *longicollis* group from which it can be distinguished by its styliform processes on the lips and by the cephalic ornamentations.

Genus II.—Veversia gen. nov.*

Oxyurids of small size; simple lips; lateral alæ present; no caudal alæ; vulva behind the middle of the body; ovejector very long; uterus single; two ovaries; spicule single; accessory piece present; genital papillæ sessile.

Type species.—*V. tuberculata* (Linstow, 1904), from *Tachysaurus rugosus*.

* This genus is named in honour of Dr. G. M. Vevers, Superintendent Zoological Gardens, London.

11.—Veversia tuberculata (Linstow, 1904).

Synon.—*Oxyuris tuberculata* Linst., 1904.

The body is slender and of small size.

The cuticle is thick, transversely striated and is furnished in both sexes with thick hairs. Von Linstow does not mention this character in his account of this form; the lateral areas are well developed and each bears a pair of thick crests running parallel to each other, along the entire length of the body; the excretory pore lies behind the bulb in both sexes and is ·87 mm. in the male and ·91 mm. in the female from the anterior end; the excretory vesicle is large and is connected to four excretory tubes running in the lateral area and arranged in the form of X. As they proceed away from the vesicle they become indistinguishable from the lateral areas.

The head is distinct; the mouth is surrounded by three conical lips pointed at their tips; the buccal cavity is short.

The œsophagus is elongated and joined to the posterior bulb by a short neck. Anteriorly the œsophagus bears rounded and finely granular knob-like outgrowths, and outside these there are fine pointed cuticular teeth, all projecting into the buccal cavity; the bulb is large, spherical and armed with chitinous blades; three œsophageo-intestinal valves project out from the bulb into the chyle-intestine; the intestine is cylindrical, forming a funnel-shaped enlargement at its anterior end; the rectum is short, 230μ long, and bears the usual rectal gland cells at its commencement, and opens to the exterior 440μ in front of the tip of the tail. The nerve ring surrounds the œsophagus in its anterior fifth and is 140μ in the male and 170μ in the female from the anterior end.

The female body is slender, 3 to 4 mm. long with a maximum diameter of 300μ at about the middle of the body; the tail is elongated, conical, 440μ long, and pointed.

The vulva is behind the middle of the body, about 1·28 mm. in front of the tip of the tail; the vagina running obliquely forwards, is elongated and about 200μ long; the ovejector is very long, it bends back in a curve and posteriorly forms a U-shaped loop; the uterus, single throughout, lies parallel to the ovejector and bifurcates anteriorly into two short

oviducts leading into the corresponding ovaries ; the ovaries are massive and club-shaped.

The eggs are bean-shaped and are embryonated *in utero*. The eggs measure 110μ by 60μ and the coiled embryos are 188μ to 190μ long.

The male is 2 to 3 mm. long, rather stout, having a maximum diameter of 250μ. The body is abruptly cut in behind the cloaca on the ventral side and is produced into a narrow tail, 145μ long, which gradually tapers towards its extremity. In front of the tail the cuticle is inflated to form lateral alæ, like those found in the genus Thelandros. In this character, therefore, it differs from the genus Tachygonetria.

There are only three pairs of papillæ, of which one pair is on the tail —caudal papillæ—at about 45μ behind the cloaca. The pre-anal pair is large and bears a posteriorly directed cuticular point ; the post-anal pair is displaced to the tip of the dorsal lip of the cloaca ; there is no ad-anal pair.

The cloacal lips are very prominent and the posterior lip protrudes as a conical outgrowth.

The spicule is elongated, stout, 90μ to 100μ in length, slightly curved and is flattened out at the head end. An accessory piece, 33μ long, supports the posterior lip of the cloaca and is sometimes absent.

Habitat. Cæcum of *Tachysaurus rugosus*.

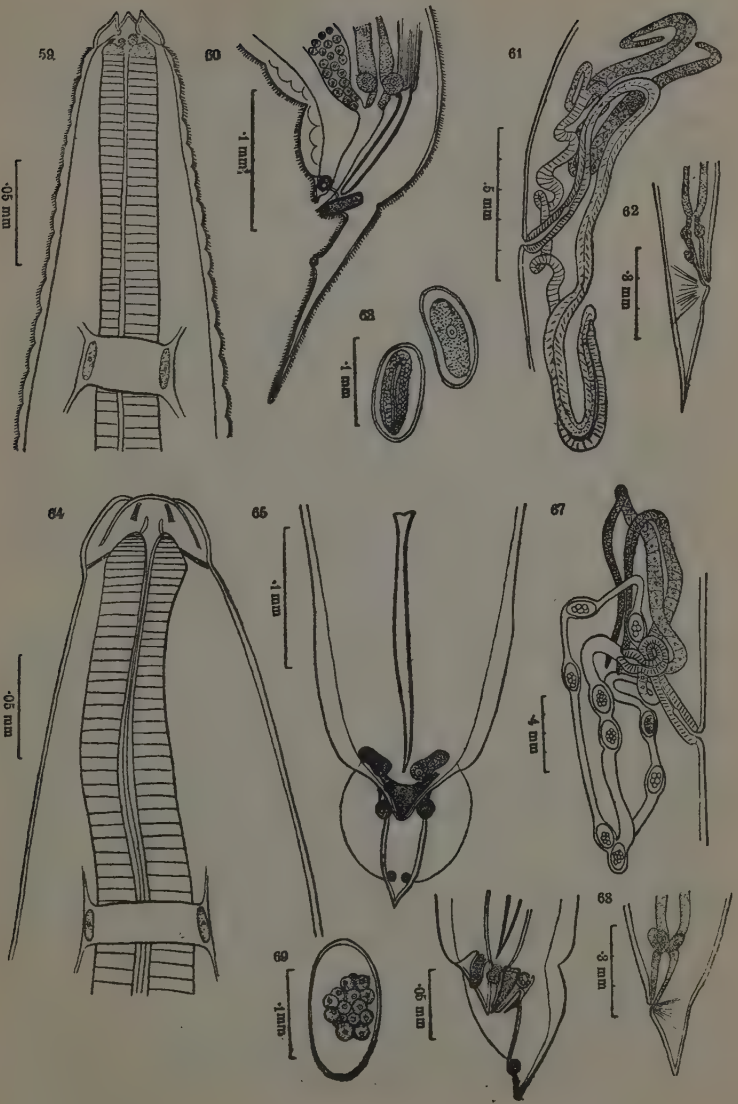
Affinities.—This form is distinctly characterised by the presence of a cuticular " hairy " coat, conical lips, thick crests running in the lateral areas, in the female, spherical knobs and teeth projecting from the anterior end of the œsophagus, very long ovejector, a single uterus and two ovaries, lateral alæ in the male and by the position of the post-anal pair of genital papillæ at the tip of the upper lip of the cloaca. It thus shows characters, some of which are of the genus Tachygonetria and others of the genus Thelandros. The presence, however, of a single uterus and two ovaries is peculiar to this form, and this alone appears to the writer to be of sufficient importance to validate the creation of a new genus for its reception.

V. tuberculata.

Fig. 59.—Head end, ventral view.

Fig. 60.—Posterior end, male, lateral view. Fig. 61.—Female genitalia.

Fig. 62.—Female tail, lateral view. Fig. 63.—Eggs and embryo.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Genus III.—Alæuris gen. nov.

Oxyurids of small or medium size; simple lips; both lateral and caudal alæ present, the latter very prominent; vulva behind the middle of the body; ovejector present terminating in a bulb; uteri two; spicule single; accessory piece present; only pre-anal papillæ pedunculated, others sessile.

Type species: *A. alæuris* from *Testudo ibera.*

12.—Alæuris alæuris sp. nov.

The body is stout, of medium size, 4 to 6 mm. long, and the males are usually smaller than the females. The cuticle is thick with fine transverse striations; at the posterior end of the male it forms lateral as well as caudal alæ; the lateral areas are well marked, being composed of a single row of large cells with spherical nuclei; the excretory pore, about 1·8 mm. in the male and 2·18 mm. in the female from the anterior end of the body; is post-œsophageal in both sexes; the excretory vesicle is large and spherical; and leads into four canals, arranged in the form of X—two anterior and two posterior—in the lateral areas in which they become obscured after a short course from the vesicle.

The head is distinctly marked off from the body; the mouth is surrounded by three lips each bearing a prominent pair of cephalic papillæ.

The œsophagus is elongated, cylindrical, about 1·425 mm. long in the male and 1·82 mm. in the female. It is joined by a narrow neck to a sub-spherical bulb provided with three chitinous blades and produced posteriorly into three triangular œsophageo-intestinal valves projecting into the lumen of the chyle-intestine; the intestine is rectilinear and is dilated anteriorly into a large pear-shaped swelling, larger than the bulb of the œsophagus; the rectum is short, about 185μ long, and is marked off from the intestine by the presence of three oval rectal gland cells; it opens to the exterior 240μ in front of the tip of the tail.

Alæuris alæuris.

Fig. 64.—Head end, dorsal view.
Fig. 65.—Posterior end, male, ventral view.
Fig. 66.—Same, lateral view. Fig. 67.—Female genitalia.
Fig. 68.—Female tail, lateral view. Fig. 69.—Egg.

The nerve ring surrounds the œsophagus at about 210μ from the anterior end of the body in both sexes.

The female body is stout, about 4·5 to 6 mm. long, with a maximum diameter of 780μ; the tail is very short, conical, and about 240μ long.

The vulva lies behind the middle of the body, about 2·3 mm. from the tip of the tail in 6 mm. long specimens; the vagina is elongated, 220μ long and is forwardly directed; the ovejector, long and muscular, is folded on itself and ends in an oval muscular bulb; the reservoir is elongated, tubular, and runs backwards; the uteri, one on each side of the reservoir, run forward and then bend back to join the elongated and club-shaped ovaries which are coiled on themselves.

The eggs are large, elongated, and measure 160μ by 80μ; they are segmented *in utero*.

The male is smaller than the female and is 4 mm. long, having a maximum diameter of 350μ. The body is stout, and bears a short tail, about 90μ long, terminating in a short conical tip. The tail is provided on either side with a semicircular caudal ala. Lateral alæ, extending back to the cloaca, are also present on the posterior end of the body. Ventrally the body is cut by a deep cleft behind the cloaca.

There are three pairs of genital papillæ surrounding the cloaca; the preanal pair is pedunculated and has a stout peduncle, while the other two pairs are sessile; the ad-anal pair is the smallest of the series. The caudal pair of papillæ are small and are inserted at the posterior limit of the caudal alæ.

The cloaca has two lips; the posterior protrudes in the form of a broad conical hood overhanging the aperture, and arising from its dorsal wall, in the angle between it and the tail, is a pair of small chitinous pointed processes; the anterior lip is simple.

The spicule is very long, 185μ in length, slender and acicular with a dilated head; the accessory piece is small, 40μ in length, and is in the form of a wide V with a thick pointed base.

The caudal glands have the same disposition of parts as in the members of the genus Tachygonetria.

Habitat.—Cæcum of *Testudo ibera*.

Affinities.—This form differs from the genus *Tachygonetria* in the presence of lateral and caudal alæ, and of a pedunculated pre-anal pair of papillæ. It stands midway between the genera *Tachygonetria* and *Thelandros*. It resembles the latter genus, in having lateral alæ but differs from it in having only one pair of pedunculated papillæ (in *Thelandros* both pairs of genital papillæ are pedunculated), caudal alæ and an accessory piece. In the presence of the caudal alæ in the male it resembles the genus *Pharyngodon*.

13.—Alæuris iguanæ, sp. nov.

Oxyurids of small size, 2 to 3·2 mm. long ; the body is rather stout.

The cuticle is thin with somewhat indistinct transverse striations ; the lateral areas are composed of large cells ; the excretory pore lies behind the bulb in both sexes, ·88 mm. in the male and ·95 mm. in the female from the anterior end of the body.

The head is not distinct ; the mouth is surrounded by three simple hemispherical lips that bear along their inner edges a small pointed tooth-like process ; there is no buccal cavity.

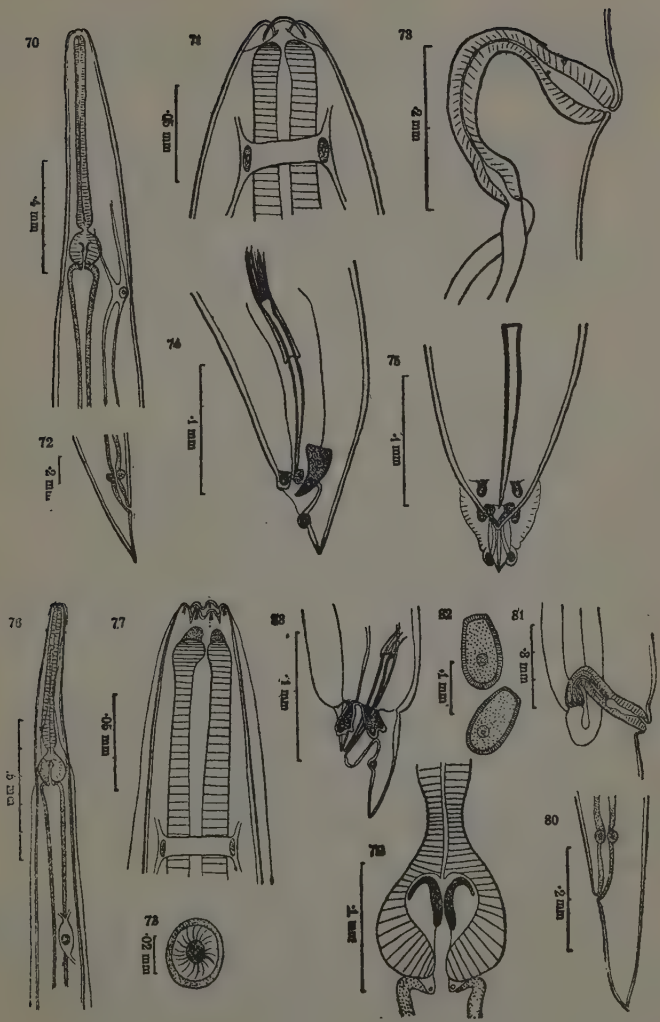
The œsophagus is long, slender, and is connected by a short neck to a large spherical bulb armed with chitinous blades ; the œsophageo-intestinal valves are small and triangular. The total length of the œsophagus, including the bulb, is ·83 mm. in the female and ·72 mm. in the male ; the intestine is rectilinear, forming anteriorly a large swelling ; the rectum is short, 120μ long ; the rectal gland cells are of the usual type ; the anus is 190μ in front of the tip of the tail.

Alæuris iguanæ, sp. nov.

Fig. 70.—Anterior end, lateral view, slightly tilted.
Fig. 71.—Head end, dorsal view. Fig. 72.—Female tail, lateral view.
Fig. 73.—Female genitalia, posterior end, showing vagina ovejector and two uteri.
Fig. 74.—Posterior end, male, lateral view. Fig. 75.—Same, ventral view.

Thelandros alatus.

Fig. 76.—Anterior end of female, showing general structure, ventral view.
Fig. 77.—Head end, dorsal view. Fig. 78.—Excretory pore, greatly enlarged.
Fig. 79.—Œsophageal bulb, showing internal armature.
Fig. 80.—Female tail, lateral view.
Fig. 81.—Posterior end of female genitalia, note gland cells in the ovejector.
Fig. 82.—Eggs with thick shell. Fig. 83.—Posterior end, male, lateral view.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The nerve ring surrounds the œsophagus in its anterior part about 280μ in the female and 54μ in the male from the anterior end.

The female body is stout, 3 to 3·2 mm. long, having a maximum diameter of 330μ across the middle of the body; the tail is short, conical, about 190μ long, and is pointed at the extremity.

The vulva is behind the middle of the body, 1·41 mm. from the tip of the tail; the vagina is short and club-shaped and is at right angles to the surface; the ovejector is long, and curves backwards in a semicircular arc to terminate in an oval muscular bulb; there is no reservoir, the ovejector being directly connected to the two uteri; the parallel uteri first pass backwards and then curve forwards; the ovaries are parallel, large, massive and club-shaped.

The eggs contain young embryos in early stages of development.

The males are smaller than the females, and are 2·1 mm. long with a maximum diameter of 260μ; the tail is short, stumpy, about 54μ long, and bears on either side a thin caudal ala with fine striations.

There are three pairs of genital papillæ round the cloaca, of which the pre-anal pair only is pedunculated, the peduncle being stout; the ad-anal and the post-anal pairs are of approximately equal size and are sessile. On either side of the tail, a little in front of its tip, there is a small sessile caudal papilla, surrounded by the caudal alæ.

The posterior lip of the cloaca protrudes as a small conical hood overhanging the cloacal aperture, and is supported by the accessory piece.

The spicule, about 145μ long, is slender and acicular and has a broad head. The accessory piece is 45μ long, large, stout and V-shaped.

Habitat.—Intestine of *Iguana tuberculata*.

Affinities. This species resembles the type species of the genus in general characters, but can easily be distinguished from it by its smaller size, the presence of teeth-like processes on the lips, the absence of the reservoir in its female genitalia, the ovoviviparous condition, the length of the spicule, and the striations on the caudal alæ.

Genus. THELANDROS Wedl, 1862.

Oxyurids of medium size ; lips deeply bilobed ; lateral alæ well developed ; no caudal alæ ; vulva behind the middle of the body, slightly protruding ; ovejector lined with glandular cells ; two uteri ; spicule single ; accessory piece generally absent ; two pairs of pedunculated genital papillæ.

Type species. *Thelandros alatus* from *Uromastix spinipes*.

14.—THELANDROS ALATUS Wedl, 1862.

Synon. *Oxyuris uromasticolla* Galeb, 1889 ; *Oxyuris uromasticola* (Galeb) Seurat, 1915.

The body is stout and of medium size gradually narrowing towards the extremities.

The cuticle is thick, transversely striated and bears lateral alæ along its entire length ; the lateral areas are well developed and are composed of large cells ; the excretory pore is far behind the bulb in both sexes. being about 1·19 mm. (male) and 1 mm. (female) from the anterior end, It is surrounded by a hard chitinous hem, followed by a ring of muscular tissue. The aperture is surrounded by an oval cuticular depression on the surface ; the excretory vesicle is large and from it arise four excretory canals—two anterior and two posterior—leading into the lateral areas.

The head is not distinct ; the mouth bears six lips each provided with a cephalic papilla ; the buccal cavity is absent.

The œsophagus is preceded by a short pharynx and is itself elongated and cylindrical, ·62 mm. long in the male, ·82 mm. in the female, and is connected by a short neck to the pear-shaped posterior bulb armed with chitinous blades. The intestine is swollen at its commencement, and the rectum is short, about 195μ long, and opens 370μ in front of the tip of the tail. The rectal glands cells are oval.

The nerve ring surrounds the œsophagus at 165μ from the anterior end of the body.

The female body is stout, straight, about 5·75 mm. long, with a maximum diameter of 250μ. Posteriorly it bears a strong tail, 370μ long and is terminated in a point.

The vulva protrudes slightly, and leads into a short vagina placed obliquely across the body; the ovejector curves backwards and is lined internally by flask-shaped glandular cells with a long neck opening into the infundibulum of the vagina; the two uteri arise from it and are opposed, the posterior uterus, after a short course, curves forwards to run parallel to the other; the ovaries are compact and long, and are entangled round the anterior part of the intestine.

The eggs are ovoid, 140μ by 80μ, and are flattened at one pole. They are provided with a thick shell lined with a thin vitelline membrane.

The male is 3·5 mm. long having a maximum diameter of 220μ. Posteriorly, behind the cloaca, the body is deeply cut from the ventral aspect and forms a narrow elongated tail 82μ long.

There are two pairs of pedunculated papillæ round the cloaca, the post-anal pair being forked at the tip. The caudal pair of papillæ is sessile and lies at about the middle of the length of the tail.

The posterior lip of the cloaca protrudes out and overhangs the cloaca as a conical nipple; it has a ventral groove through which the spicule projects. The ventral lip is simple.

The spicule is short, needle-shaped, and 80μ to 90μ long. An accessory piece is absent but in a few specimens its position is indicated by a triangular and hyaline structure.

Habitat.—Cæcum of *Uromastrix hardwickii*.

Affinities.—This species, which is the type of the genus *Thelandros*, offers some resemblance to the genus *Pharyngodon* in having pedunculated genital papillæ, lateral alæ, and a similar posterior cloacal lip. These characters differentiate it from the genus *Tachygonetria*, which genus it resembles in the position of the vulva, nature of the female genitalia, and the general characters of the excretory organs. It can be derived from the genus *Pharyngodon* by the loss of caudal alæ and backward shifting of the vulva behind the middle of the body.

Genus V.—Pharyngodon Diesing, 1861.

Oxyurids of small size; lips simple or bilobed; both lateral and caudal alæ present; vulva in front of the middle of the body, immediately

behind the excretory pore ; ovejector absent ; two uteri very long and coiled ; spicule single ; accessory piece absent ; genital papillæ pedunculated and supporting the caudal alæ.

Type species. *Ph. spinicauda* (Dujardin, 1845) from *Lacerta muralis*.

15.—Pharyngodon hindlei sp. nov.

The body is stout and gradually narrows towards the extremities. It terminates in both sexes by a thin elongated caudal tail, having a thick and smooth cuticular covering.

The cuticle is thick and transversely striated ; the lateral areas are large and are composed of several large cells ; the lateral lines are pierced by a pair of thick parallel crests running close together, and extend in the female from behind the œsophageal bulb to beyond the anus, where they both unite to form a V-shaped structure ; in male they extend as far back as the cloaca, forming lateral alæ. The excretory pore is behind the œsophageal bulb, about ·86 to ·88 mm. from the anterior end of the body ; it is strengthened by a thick chitinous rim and carries a row of stout elongated cirri along its posterior edge. These cover the excretory pore, and appear to be modified cilia. It leads into a long excretory reservoir connected to four small excretory canals, arranged in the form of X. The canals are usually smaller than those found in the other genera of reptilian Oxyurids, and, further, the anterior canals are smaller than the posterior ones.

The head is not distinct ; and the mouth is surrounded by three slightly bilobed lips ; there is no buccal cavity.

The œsophagus is short and stout and is connected by a short neck to the posterior bulb, which is armed with chitinous blades. Posteriorly there are three triangular œsophageo-intestinal valves projecting into the chyle-intestine. The total length of the œsophagus is ·44 mm. in the male and ·64 mm. in the female. The intestine is rectilinear, being slightly dilated at its anterior end to form a pear-shaped swelling. The rectum is short, about 140μ in length, and opens 1·22 mm. in front of the tip of the tail.

The nerve ring surrounds the œsophagus in its anterior third in the male and the anterior fourth in the female. It is 163μ in male and 160μ in female from the anterior end of the body.

The female body is stout, 4 to 6 mm. long. The tail is 370μ long and is sharply marked off from the body running back in continuation of the ventral side.

The vulva is in front of the middle of the body and lies immediately behind the excretory pore at 70μ from it. The vagina is very long and runs parallel to the body wall. Posteriorly it curves back and crosses over to divide into two uteri directed in opposite directions. The uteri make several coils round each other and join the large club-shaped ovaries entangled in the body with other organs.

The eggs are very long and narrow, flattened along one side and measure 139μ by 42μ. The shell is thin and is lined with a clear vitelline membrane. It has an operculum at one end; they are laid in a fairly advanced stage of segmentation.

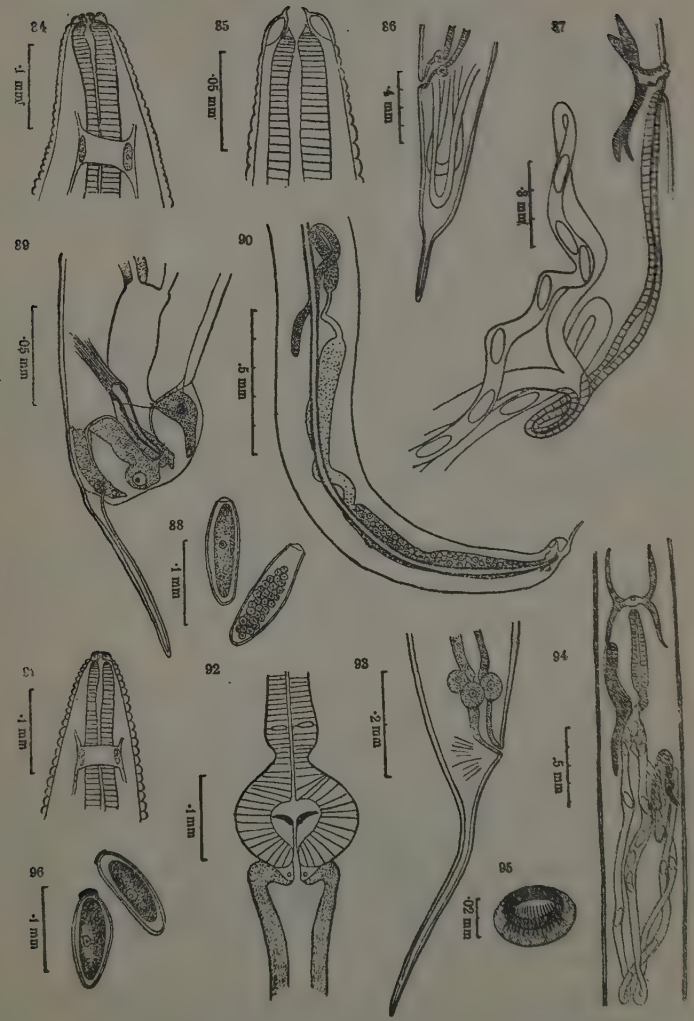
The male is smaller than the female, measuring 2 to 4 mm. in length. The body is abruptly cut behind the cloaca on the ventral side, and continues back as a narrow elongated tail 125μ to 150μ in length. The cuticle bears on either side a lateral ala and behind the cloaca arises a pair of caudal alæ, one on either side of the tail, giving it the appearance of a bursa. It is supported by three pairs of elongated pedunculated papillæ. The ad-anal pair of papillæ is bifurcated at its extremity and is the largest of the series, one of its branches is simple and the other is large and spherical.

Pharyngodon hindlei.

Fig. 84.—Head end, female, ventral view.
Fig. 85.—Head end, male, ventral view.
Fig. 86.—Female tail, lateral view.
Fig. 87.—Female genitalia and excretory system, lateral view.
Fig. 88.—Eggs with operculum.
Fig. 89.—Posterior end, male, lateral view.
Fig. 90.—Male genitalia, lateral view. Lateral alæ shown.

Pharyngodon sp.

Fig. 91.—Head end, ventral view.
Fig. 92.—Œsophageal bulb with its armature.
Fig. 93.—Female tail, lateral view.
Fig. 94.—Female genitalia and excretory system.
Fig. 95.—Excretory pore, greatly enlarged, showing stout cilia along its posterior border.
Fig. 96.—Eggs with plugs.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Besides these there are two pairs of papillæ attached to the body wall by a wide base; one pair—caudal papillæ—is attached to the first quarter of the tail at the point of termination of the caudal alæ, and the other pair is found in front of the pre-anal pair of papillæ.

The spicule is short and stumpy, about 42μ in length, and has a rounded head. There is no accessory piece.

The posterior lip of the cloaca is prolonged beyond the aperture as a broad nipple-like outgrowth overhanging the cloaca. The spicule projects at its base.

Habitat.—Intestine of *Tiliqua senicordis*.

Affinities.—This species is named in honour of its donor, Dr. E. Hindle, who presented a large collection of Helminths to the department. It resembles *Ph. auziensis* of Seurat, in having forked ad-anal genital papillæ but can readily be distinguished from it by the nature of the crests in the lateral lines, the crests in *Ph. auziensis* being parallel, and not meeting behind the cloaca to form a V-shaped structure; it also differs from that species in the shape of the spicule and of the eggs.

16.—Pharyngodon sp. (female specimens only).

The body is elongated, stout, and measures 3 to 4 mm. in length, tapering gradually behind the anus to form a long narrow tail about ·54 to ·7 mm. long, and is covered with a thick cuticle.

The head is not distinct, and the mouth is surrounded by three bilobed lips. There is no buccal cavity.

The lateral areas are well developed, and each bears two parallel crests, extending from the level of the œsophageal bulb to the posterior end, where they terminate without uniting to enclose a V-shaped area. The excretory pore is situated behind the bulb at ·86 mm. from the anterior extremity and is strengthened by a thick cuticular hem guarded along its posterior margin by a row of thick cilia. The excretory reservoir is transversely elongated and leads into four short excretory canals—two anterior and two posterior—in the lateral areas.

The œsophagus varies from ·4 to ·55 mm. in length, and is joined on to the posterior bulb by a short neck. The bulb is spherical and is armed with three chitinous blades. The œsophageo-intestinal valves are in

the usual position and project into the chyle-intestine. The rectum is short, about 140μ long, and bears the usual rectal gland cells. The anus is ·54 mm. from the tip of the tail.

The vulva is in front of the middle of the body, and opens immediately behind the excretory pore about 80μ from it. The genital organs occupy a space between the excretory pore and the anus. The vagina is elongated, 450μ long, and narrows behind before dividing into two parallel uteri. The uteri are very long, extending backwards as far as the cloaca, where they bend forwards and pass in front of the tail towards the anterior end to join the club-shaped ovaries, which are directed posteriorly.

The eggs are large, and are provided with a thick rounded plug at one pole. They measure 132μ by 60μ, and the shell is lined with a clear vitelline membrane.

Habitat.—Intestine of *Egernia cunninghami*.

Affinities.—This species resembles *Ph. auziensis* in the presence of an elongated vagina, the plug of the eggs, and by the nature and disposition of the crests in the lateral area, but since males are not available it cannot be assigned to a definite species. It may be noted that here also the excretory pore is bordered along its posterior margin by a row of thick "cilia," and may be a generic character.

17.—Oxyuris sp.

The body is stout, about 6 mm. long, with a maximum thickness of 590μ. The tail is short, 270μ long, and is surrounded by a collar of coarse granular material.

The cuticle is thick and is finely striated; the lateral areas are well developed and have the usual structure; the excretory pore is behind the bulb, about 1·41 mm. from the anterior end of the body, and lies in the centre of an oval depression on the ventral side; it is joined on to the excretory reservoir that is connected to four excretory canals, two anterior and two posterior, running in the lateral areas.

The head is marked off from the body by a slight constriction, and the mouth is surrounded by three lips deeply bilobed. Each lobe bears a cephalic papilla that projects out anteriorly. There is no buccal cavity.

The œsophagus is stout and is slightly constricted in the middle of its length, giving it the appearance of being composed of two distinct parts. The posterior part is enlarged into a pear-shaped bulb without chitinous blades or teeth. The œsophageo-intestinal valves are in the usual position. The intestine is rectilinear, forming a pear-shaped dilation at its anterior end. The rectum is comparatively long, 250μ in length, and opens to the exterior at 250μ in front of the tip of the tail. The rectal glands cells are of the common type.

The nerve ring surrounds the anterior bulb of the œsophagus, about 170μ from the anterior end of the body.

The vulva, 2·48 mm. from the tip of the tail, does not protrude. The vagina is short, obliquely directed forwards; the ovejector is long, recurved backwards, and connected to the reservoir; two uteri lead forwards from the reservoir; ovaries are long and club-shaped.

The eggs are large, 145μ by 80μ, and are in a state of segmentation *in utero*.

Habitat.—Cæcum of *Testudo ibera*.

Affinities.—Since only females are found it is not possible to ascribe this form to any particular genus.

18.—Oxyuris sp.

Only the females were found; no male was available.

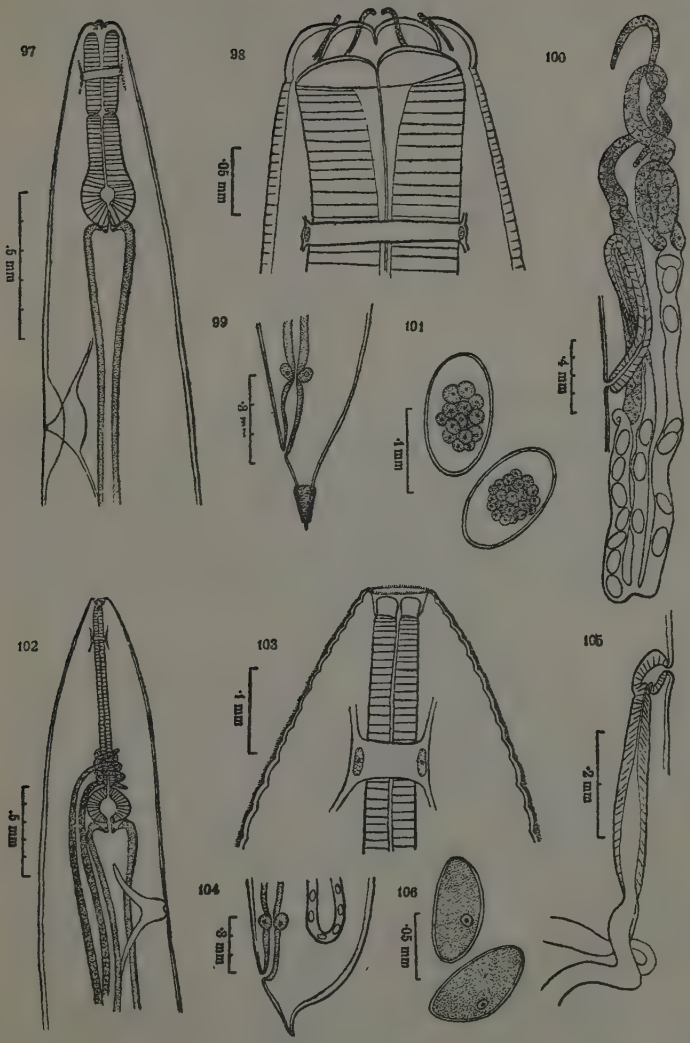
The body is stout, and is 4 to 5 mm. in length, with a maximum thickness of 740μ. At the posterior end it forms a short tail, 350μ long, terminating in the form of a mucron.

Oxyuris sp.

Fig. 97.—Anterior end, lateral view.
Fig. 98.—Head end, dorsal view.
Fig. 99.—Female tail, lateral view.
Fig. 100.—Female genitalia.
Fig. 101.—Eggs.

Oxyuris sp.

Fig. 102.—Anterior end, lateral view.
Fig. 103.—Head end, ventral view.
Fig. 104.—Female tail, lateral view.
Fig. 105.—Female vagina, ovejector and ends of uteri.
Fig. 106.—Eggs.


97
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98
·05 mm
99
·3 mm
100
·4 mm
101
·1 mm
102
·5 mm
103
·1 mm
104
·3 mm
105
·2 mm
106
·05 mm

The cuticle is thick and is distinctly annulated, being covered over with thick hair. The lateral areas are well marked ; the excretory pore lies behind the bulb, about 1·77 mm. from the anterior end of the body ; excretory reservoir is spherical and is connected to four short excretory canals—two anterior and two posterior in the lateral areas. Their size and disposition reminds one of the genus Pharyngodon.

The œsophagus is long, terminating in a large spherical bulb behind, and is 1·3 mm. long ; the œsophageal bulb is unarmed ; the intestine is swollen at its anterior end to form a pear-shaped dilation ; the rectum is 280μ to 300μ in length, and is marked off from the intestine by the rectal gland cells ; the anus is 350μ in front of the tip of the tail.

The nerve ring surrounds the œsophagus at 120μ from the anterior end of the body.

The vulva is in front of the middle of the body, 2·83 mm. from the tip of the tail, and is far removed from the excretory pore ; the vagina is very short, and dilated ; it is directed backwards ; the ovejector is long and also directed posteriorly ; the two uteri run back towards the posterior end, coiling on each other they curve forwards and join long ovaries twisted round the œsophagus in front of the œsophageal bulb.

The eggs are large, convex on one side and flat on the other, and measure 78μ by 40μ. They were not segmenting in the body of the worm.

Habitat.—Intestine of *Tachysaurus rugosus*.

Affinities.—This species resembles the genus *Pharyngodon* in having the vulva in front of the middle of the body, a backwardly directed vagina and short excretory canals. It, however, differs from the latter in the presence of the ovejector, and short tail, and the absence of the crests in the lateral areas. The characters of the vagina and the ovejector indicate that it may be related to the genus *Thelandros*, but the position of the vulva in front of the middle of the body does not support its inclusion into that genus. It is very difficult, owing to the absence of the males, to definitely locate its position. It is, therefore, described under a common genus *Oxyuris* as applied by the earlier workers.

Phylogeny of the Oxyurids of Reptiles.

Seurat (1917) regards the Oxyurids of reptiles as a group of very primitive forms, and based his conclusions on the simplicity of their

organisation. The writer does not regard these forms as primitive, but as highly specialised, having attained simplicity in their organisation through degeneration.

That these forms are specialised is shown by the fact that vivipary, which is regarded as a higher type of development, is exhibited by several members of the oxyurids from reptiles. We can trace the gradual passage of ovipary into vivipary even in the group under consideration. Thus, in the members of the genus *Pharyngodon*, in which degeneration is least, ovipary is prevalent. In the members of the genus *Alæuris*, which are simpler than those of the previous genus, we find a transition in that *A. alæuris* is oviparous, and the segmentation has set in while the eggs are still in the body of the parent; and *A. iguanæ* is ovo-viviparous, a step in advance of the previous species. In *V. tuberculata*, again, the embryos are developed while the eggs are still within the uterus (ovo-viviparous). Coming to the genus *Tachygonetria*, which has the simplest organisation, we find that in some species the eggs are in an advanced stage of segmentation, while in others free embryos are present *in utero*. *T. vivipara* is the type of the latter form of development. Therefore, it appears that the group is not primitive but rather a specialised one, in which simplicity has been attained by degeneration. This degeneration of characters is well marked in the nature of genital papillæ. In the genus *Tachygonetria* some species show a typical number of genital papillæ for the family, *i.e.*, three pairs of circumcloacal and one pair of caudal papillæ. In these forms, however, we find that the ad-anal pair is generally the smallest, and shows a further tendency towards degeneration. From a general review of the species described in the present communication under the genus in question it would appear that the adanal pair of papillæ are absent in some. That the absence of the adanal pair is due to degeneration is apparent from the fact that an examination of young males of *T. pusilla* and *T. longicollis* indicates the presence of full number genital papillæ, whereas in the adult the adanal pair is absent. In a few specimens of *T. longicollis* the position of the adanal pair is indicated by the presence of an irregular mass of granular tissue. It would thus appear that degeneration of genital papillæ occurs in the course of development of these oxyurids, beginning with the full number in the young forms and their subsequent reduction in the adult.

Taking this as our working hypothesis, we can start with the genus *Pharyngodon*, where an oviparous condition is found. In this genus, all the circumcloacal papillæ are pedunculated, being provided with very long ray-like peduncles. There are also the lateral and caudal alæ present. In the genus *Thelandros*, also exhibiting ovipary, degeneration sets in and we find only two pairs of pedunculated papillæ, and where a third pair of circumcloacal papillæ are present they are sessile. The caudal alæ are absent in this genus, there being only lateral alæ. On the other hand the caudal alæ are present in the genus *Alæuris*, but the tail is reduced and the genital papillæ have undergone a further reduction so that only one pair of genital papillæ (*i.e.*, preanal) is pedunculated. In the genus *Tachygonetria* there is a total loss of the peduncles of the genital papillæ which are sessile throughout the genus and the adanal pair is reduced in some and completely absent in the adults of others. The caudal and lateral alæ are also absent and both oviparous and viviparous forms are met with. Lastly, in the genus *Veversia*, there are only two pairs of genital papillæ and of these the post-anal pair tends towards reduction in size. The caudal alæ are absent.

Thus we can trace a gradual degeneration of characters leading towards simplicity of organisation which according to the writer is a secondary modification in the group under review.

Ciliation in Nematodes.

It has been generally held that Nematodes are devoid of ciliation at any stage in their development. This absence of cilia has been correlated, and perhaps correctly, with the tendency to form thick cuticle. (Shipley.)

During recent years the presence of cilia in the group has been demonstrated in the intestinal lining of several genera of Nematodes under different names: "*bordure en brosse*" (Prenant); "*stäbchen*" (Martini); "*stabchenlage*" (Jägerskiöld), etc., and later it has been shown by Hetherington (1923) that they are all modified forms of cilia. He also regards the presence of ciliation as a primitive character, especially the external ciliation and that its loss is due to the tendency of cuticularisation.

The writer has found the cilia guarding the posterior edge of the excretory aperture, as thick cirri, in the genus *Pharyngodon*. The excretory aperture is, further, supported by a ring of cuticular tissue. The absence of the ciliation guarding the excretory aperture of other genera described in the present communication further supports the line of argument advanced by the writer in regarding the degeneration of characters as leading towards simplicity of organisation.

Family. Atractidæ Travassos, 1920.

Œsophagus with an anterior and posterior bulb; viviparous; the female genital system single; vulva is placed posteriorly or in common with the anus; spicules two, unequal; an accessory piece is present.

Genus. Atractis Dujardin, 1845.

"Mouth with six distinct lips, provided with cephalic papillæ that may project into conical processes; vulva distinct from the anus; no ovejector; two unequal spicules and an accessory piece present; one pair of precloacal genital papillæ, three adcloacal pairs, and a variable number of post-cloacal papillæ." (Khalil.)

19.—Atractis dactyluris (Rud., 1819).

Synon. *Ascaris dactyluris* Rud., 1819; *Atractis dactylura* Dujardin, 1845; *Atractis brevicollis* Schneider, 1866; *Atractis granulosa* Raill. and Henry, 1912.

The body is slender, of medium size, straight in the female, curved ventrally in the male at the posterior end. The males are smaller than the females and are 4 to 4·5 mm. in length, the females being 5 to 6 mm. long.

The cuticle is thick, finely striated, the striations being faint; the excretory pore is an oval aperture lying behind the bulb in both sexes; the excretory reservoir is joined on to four excretory canals—two anterior and two posterior—and is surrounded by strong muscle-fibres. The aperture has a chitinous rim.

The head is not distinct; the mouth is surrounded by six lips, each being provided with a cephalic papilla that protrudes out at the anterior end. There is no buccal cavity.

The œsophagus consists of two bulbs connected together by a long connective; the anterior bulb is club-shaped and is cut off from this connective by a slight constriction. The posterior bulb is a spherical dilatation of the connective and is armed with chitinous blades supported on transversely placed chitinous plates. The wall of the bulb bears the usual scales described in *T. vivipara*. The œsophageo-intestinal valves project into the chyle intestine as three triangular flaps. The intestine is rectilinear and straight; the rectum is short, about 140μ in length, and is marked by three rectal gland cells at its junction with the intestine. The anus is 830μ in front of the tip of the tail.

The nerve ring surrounds the œsophagus at ·48 mm. from the anterior end of the body.

The female is straight and terminates posteriorly in a long conical pointed tail about 830μ long.

The vulva lies immediately in front of the anus about 60μ from it, and has protruding lips; the vagina is short, about 200μ long, and leads directly into a very long wide uterus that narrows anteriorly to form a slender oviduct twisted back on itself, and is joined to a short massive club-shaped ovary, full of dense protoplasm. The uterus is full of embryos.

The male is smaller than the female, and is 4 to 4·5 mm. long. Posteriorly, the body suddenly narrows to form a slender tail, 247μ long. The total length of the animal behind the cloaca is 530μ.

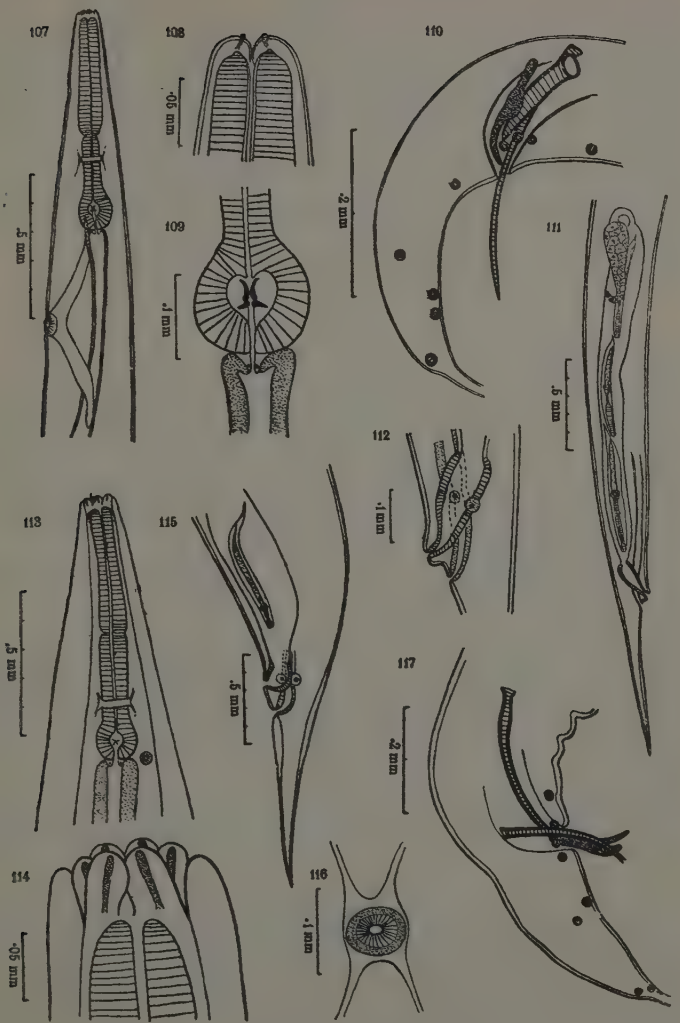
There are three pairs of circumcloacal papillæ that are stalked. In front of the cloaca there is only one pair of pedunculated papillæ, and

Atractis dactyluris.

Fig. 107.—Anterior end, lateral view.
Fig. 108.—Head end, ventral view.
Fig. 109.—Œsophageal bulb showing internal armature.
Fig 110.—Posterior end, male, lateral view.
Fig. 111.—Posterior part, female, showing female genitalia, anus, tail, etc.
Fig. 112.—Posterior end, female, showing relative position of the anus and vulva.

Atractis orlleppi.

Fig. 113.—Anterior end, ventral view.
Fig. 114.—Head end, ventral view.
Fig. 115.—Posterior end female, lateral view, showing a part of the genitalia also.
Fig. 116.—Excretory pore and its connections.
Fig. 117.—Posterior end, male, lateral view.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behind the cloaca between it and the tail there are five pairs of papillæ, three ventral and two dorsal. Their exact position is indicated in the Fig. 110.

There are two unequal spicules and an accessory piece. The spicules are transversely striated, and their relative measurements are :—The longer spicule is tapering and 327μ long, with a maximum diameter of 18μ near the head. The shorter spicule is 130μ long and is stouter than the other, being 25μ in diameter. The accessory piece swollen in the middle, and is curved inwards posteriorly. Its length is 147μ and has the thickness of 25μ at its swollen part.

Habitat.—Stomach of *Testudo tabulata*.

20.—ATRACTIS ORTLEPPI, sp. nov.

The body is stout and is of medium size.

The cuticle is thick and is finely striated, bearing a pair of lateral alæ extending on either side of the body. The excretory pore is in front of the bulb in the male and at the level of the bulb in the female. It is surrounded by a chitinous rim and has a strong muscular sphincter round it. The excretory vesicle is oval and is connected to four excretory canals running in the lateral areas.

The head is indistinct, and the mouth is surrounded by six distinct lips, each bearing a cephalic papilla.

The œsophagus, ·85 to ·88 mm. long, consists of two bulbs connected together by an elongated connective. The posterior bulb is sub-spherical and is armed with chitinous blades ; the intestine is simple and rectilinear ; the rectum is 200μ long and opens to the exterior at 970μ in front of the tip of the tail.

The nerve ring surrounds the posterior part of the connective about ·64 mm. in the male and ·73 mm. in the female from the anterior end of the body.

The female is 6 to 7 mm. long, and is stout, terminating posteriorly by an elongated tail about ·97 mm. long. The cuticle is slightly dilated behind the anus round the anterior end of the tail.

The vulva is not protruding and lies about 160μ in front of the anus ; the vagina is short, about 130μ long, and leads into an elongated uterus full of embryos. The ovary is single and club-shaped.

The male is smaller than the female, 5·5 to 6·5 mm. long, gradually tapering to form a tail, which is ·88 mm. long. It is not so distinctly cut up from the body as in *A. dactyluris*.

There are two unequal spicules, slender and transversely striated. The larger spicule is 465μ long with a maximum diameter of 22μ at the head end. The smaller spicule is slightly forked at the tip, and is 240μ long with a maximum diameter of 20μ near the head end. An accessory piece is present, and is short and narrow, about 140μ long and 18μ thick.

There are three pairs of circumcloacal papillæ surrounding the cloaca; one pair of pre-cloacal and four pairs of post-cloacal papillæ. Of the post-cloacal papillæ two are dorsal and two ventral.

Habitat.—Stomach of *Podocnemis unifilis*.

Affinities.—This species is named after its donor, Dr. R. J. Ortlepp, in grateful appreciation of his assistance in the work. It differs from all other species of Atractis in having lateral alæ, four pairs of papillæ (post-cloacal) and forked nature of the smaller spicule.

The genus *Atractis* was originally grouped with Ascaris and then with Oxyuris. Railliet and Henry (1916) definitely assigned it with *Oxyuroidea*, under a separate family, and included in it all the forms with two unequal spicules and an accessory piece. Travassos (1920) removed the genus from the superfamily *Oxyuroidea* and included it under a superfamily *Rhabdiasoidea*, a group of forms with heterogeneous characters whose exact nature and affinities are not definitely known, and created a new family, *Atractidæ*, for the reception of this genus along with several others. Baylis and Daubney (1922) pointed out that the genus *Atractis* should be removed from this superfamily and classed with *Oxyuridæ*. The conclusions of the writer thoroughly favour its removal from the superfamily *Rhabdiasoidea*, on the ground that the genus *Atractis* shares with the *Oxyuroidea* certain characters that ally it with the family *Oxyuridæ*.

The presence of three pairs of circumcloacal papillæ, and double-bulbed œsophagus seem to be of sufficient value to put it under the superfamily *Oxyuroidea*. The important character of the presence of three lips in the superfamily can easily be explained by stating that the lips in the genus *Atractis* have been deeply bilobed to give it the appearance of six lips, as is also the case in several species described under *Tachygonetria*.

On the presence of the following characters, therefore, it is assigned to the family *Atractidæ* created by Travassos :—

" Forms with two unequal spicules and an accessory piece, vulva behind the middle of the body, either separate or joined with the anus to form a cloaca in the female, single female genitalia."

Travassos (1920) included under this family the genus *Labiduris*, which was classed by Railliet and Henry (1916) under the forms with two equal spicules. As will be indicated in the following description this genus cannot be classed with either of them and hence has been removed from the family *Atractidæ* Travassos, leaving *Atractis*, *Rondonia* and *Leiperenia*.

Family Labiduridæ, fam. nov.

Genus. Labiduris Schneider, 1866.

Rudolphi (1819) described a nematode from the intestine of North American land turtle, *Testudo tabulata*, under the specific name *Ascaris gulosa*. Diesing (1851) found the same form in several other hosts, *Chelonoides tabulata*, *Rhinemys nasuta* and *Testudo græca*. This species differs remarkably from the genus *Ascaris* in many important points, and hence Schneider (1866) erected for its reception a new genus, *Labiduris*, in which for the time being it was the only species. Schneider, in his description, mentions that the characters of the genus were exemplified by the characters of the species described, so that the generic diagnosis is equivalent to the specific diagnosis.

Von Linstow (1899) in the course of his investigation described another species, *Labiduris zschokkei* from the same host, and also gave a generic diagnosis. He, however, distinguished his species from *L. gulosa* by the relative length of the tail in both sexes and the number of precloacal papillæ in the male.

Recently Chapin (1924) considered the two specific names as synonyms, as he thinks that the differences indicated by von Linstow are not constant. Chapin further found a great range of variations in the length of the spicules, the number of precloacal papillæ and the length of the tail in both sexes. A detailed study of a large number of specimens belonging to both the species indicates that the range of variation in the number of precloacal papillæ does exist, as mentioned by Chapin, but the differ-

ences are well marked in the length of the tail in the two forms. In *L. gulosa* the tail varies between ·4 mm. and ·5 mm. in the male and ·9 to 1·1 mm. in the female; while in *L. zschokkei* the variations are ·09 to ·15 mm. (male) and ·35 to ·45 mm. (female). Besides, there are certain other points in which the two species differ. The differences will be indicated in the course of their descriptions. I, therefore, maintain that the two species are valid, and unless it is shown by a study of their embryology that the species with short tail gives rise to the species with long tail and *vice versa*, I find no justification for uniting the two species.

Both Schneider (1866) and von Linstow (1899), in their brief descriptions, have omitted to describe certain important features in the morphology of these worms, and recently even Chapin (1924) has failed to recognise them, though he fuses the two species after a very intimate study. It is, therefore, necessary to elucidate their anatomy. The present study modifies the generic diagnosis given by von Linstow (1899).

It may, however, be stated that the writer has found certain very prominent features in the anatomy of these worms that necessitate the erection of a new family *Labiduridæ*. This point will be discussed later on after the description of the species.

The generic diagnosis in a modified form is as follows :—

The head with a ventral mouth, three bilobed lips projecting anteriorly, each lateral lip with a backwardly running process terminating in a comb-like frill; buccal cavity followed by a prepharynx; the œsophagus with three bulbs; female genitalia single throughout; vulva posterior; viviparous; two equal spicules; 20 to 24 pairs of papillæ including two pairs on the lateral lobes surrounding the cloaca.

Type species. *Labiduris gulosa* (Rud., 1819), Schneider 1866, from *Testudo tabulata*.

21.—Labiduris gulosa (Rudolphi, 1819) Schneider, 1866.

Synon. *Ascaris gulosa* Rud., 1819.

The body is stout, about 6 to 7 mm. (male) and 7 to 8 mm. (female), terminating in both sexes by a long slender pointed tail.

The cuticle is thick and is transversely striated; the excretory pore is 1·23 mm. from the anterior end of the body, and is situated at about the level of the second bulb of the œsophagus.

The anterior end of the body is very complicated. The mouth opening is ventral and in front is bounded by three strongly muscular lips of a remarkable constitution. The dorsal lip is distinct anteriorly from the lateral lips, but posteriorly is not well marked from the lateral lips. It bears a large chitinous outgrowth springing from its ventral aspect overhanging the anterior limit of the mouth, meeting the lateral lips across, and thereby completely closing the mouth from in front by forming a flat platform. There is also a small tooth-like process behind this platform. The lateral lips are separate from each other ventrally and are also bilobed. Arising from the anterior end of each of the two lateral lips is an outgrowth that curves back posteriorly on the ventral side, widening behind and thus overlapping each other and forming a pair of flaps over the mouth. These lobes bear a frill of bristle-like processes arranged along their posterior free margin, thus giving it the appearance of a comb. Probably it is sensitive, and serves as an organ to test the quality of the food, and may serve, in addition, as a strainer. The mouth leads into a vestibulum that curves backwards and is limited in front by the platform described above.

The vestibulum is followed by a small prepharynx, 80μ long. The œsophagus is also peculiarly constituted, and is composed of several parts having three bulbs. The first bulb is elongated, club-shaped, and its wall is divisible into three sections, each forming a side of the triangular lumen. It is strongly muscular with a thick cuticular lining. The next part is elongated muscular tube, also lined with cuticle, and is joined

Labiduris gulosa.

Fig. 118.—Anterior end, ventral view.

Fig. 119.—Head end greatly enlarged, ventral view, showing pectine-bearing lobes.

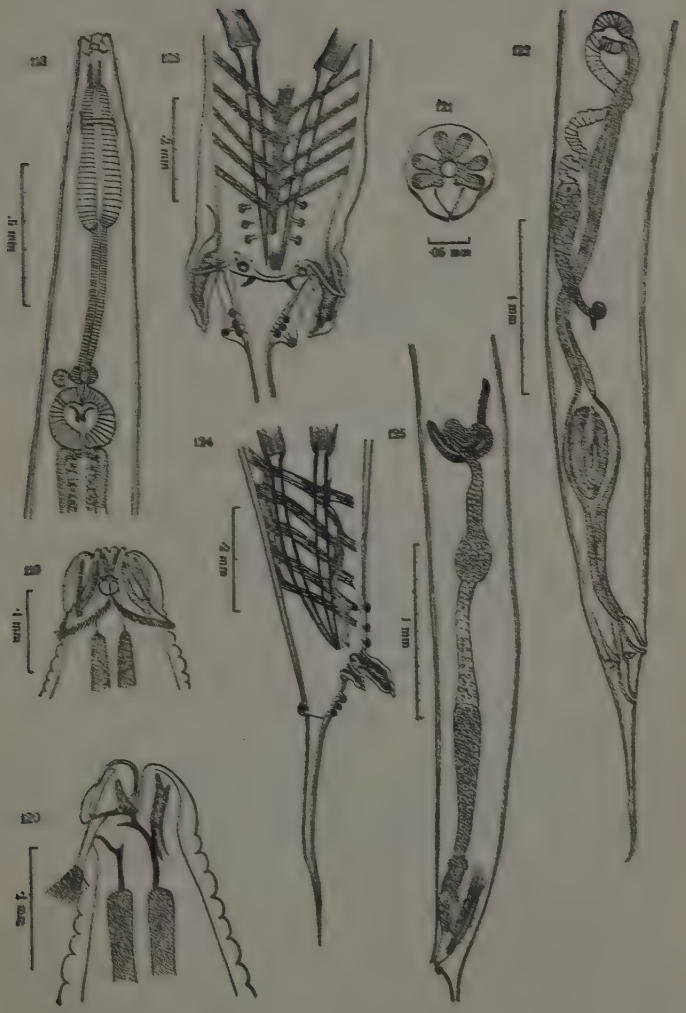
Fig. 120.—Head end, lateral view, showing vestibulum and the lips with pectine-bearing processes.

Fig. 121.—End-on view of the head.

Fig. 122.—Female genitalia. Note ovejector preceding the uterus.

Fig. 123.—Posterior end, male, ventral view. Showing spicules, accessory piece, papillæ, barbs on the ventral lip of the cloaca, and dorso-ventral muscles.

Fig. 124.—Same, lateral view. Fig. 125.—Male genitalia.



posteriorly to a small spherical bulb, having a maximum diameter of 60μ. This second bulb is connected to the posterior bulb by a short neck 15μ long. The third bulb is large, spherical, and is armed, as in *Tachygonetria*, with chitinous blades. The œsophageo-intestinal valves project into the lumen of the chyle intestine. The intestine is rectilinear, gradually narrowing towards the posterior end, and is lined by a layer of large epithelial cells, each with a large nucleus. The rectum is short, about 230μ long, and the rectal gland cells are very peculiar and characteristic. Each cell is triangular in optical section and bears two outgrowths, one attaching it to the body wall across, and the other is prolonged into very long fibres running obliquely forwards, which are ultimately joined to the body wall. Thus, it is actually in the form of a ligament connecting the rectum to the body wall by two processes.

The nerve ring surrounds the first bulb of the œsophagus at 325μ from the anterior end of the body. It bears large ganglion cells.

The female is larger than the male and terminates in a long tail, varying in length between ·9 and 1·1 mm.

The vulva is slightly protruding, and is 290μ in front of the anus. The vagina is short and wide and is 200μ long ; the uterus is elongated, muscular, and is distended with large embryos. Anteriorly the uterus is connected to a spherical ovejector having a maximum diameter of 200μ ; which is preceded by an elongated oviduct directed backwardly. The ovary is single and is club-shaped. The chief point in the nature of the female genitalia is that it is single throughout and has the ovejector preceding the uterus and not following it as in other forms.

The male is 6 to 7 mm. long with a maximum diameter of 480μ. It has a very powerful development of the dorso-ventral muscles in the posterior part of its body. Figs. 123 and 124 indicate their course within the body. Posteriorly it narrows to form an elongated tapering tail varying between ·4 mm. and ·5 mm. in length.

The cuticle is slightly dilated to form lateral alæ round the posterior end and also enclose the posterior papillæ. Behind the cloaca the body is abruptly cut and narrows down. It bears two pairs of unequal lobes round the cloaca, each terminating in a papilla. On the ventral side, on either side of the ventral lip of the cloaca, there is a small pedunculated papilla. In front of the cloaca there are three pairs of pedunculated

papillæ, but sometimes as many as five pairs have been observed. There are four pairs of post-cloacal papillæ also pedunculated, supporting the cuticular expansion. Of these four pairs, three pairs are ventral and one pair is dorsal. The ventral lip of the cloaca bears a pair of cuticular pointed processes.

There are two equal spicules, broad and tapering, measuring approximately 425μ in length. Sometimes an accessory piece is present and its shape is shown in Fig. 123.

The male genitalia consist of a single coiled testis dilating posteriorly into a spherical capsule ; this is followed by a long duct widening in its course, and then narrowing at its external opening. A little in front of its opening into the cloaca it bears a pair of irregularly lobed vesiculæ seminalis.

Habitat.—Intestine of *Testudo tabulata.*

22.—Labiduris zschokkei Linstow, 1899.

Syn. *L. africana* Gedoelst, 1916.

The body is stout, 7 to 8 mm. long, terminating in both sexes in a short conical tail. The males are smaller than the females. There are lateral papillæ arising from the body wall at various levels.

The cuticle is thick and transversely striated ; the excretory pore is in front of the second bulb, being 1·18 mm. from the anterior end of the body.

The head is distinct and the mouth is ventral, being bounded in front by three bilobed lips that have the same general structure as of those described for *L. gulosa.* It, however, differs from that species in the lobulation of the dorsal lip which is, in the present form, divided into small semi-circular lobes presenting a crenated margin. There are the usual pectine-bearing lobes arising from the lateral lips.

The vestibulum has the same character as that found in *L. gulosa.* There are the usual lateral teeth projecting into it from the lateral lips. The prepharynx is long and bears small chitinous teeth projecting into the vestibulum ; these teeth are absent in *L. gulosa.* The œsophagus has three bulbs in its course ; the second and the third bulbs are larger than those in *L. gulosa.* The second bulb has a diameter of 90μ, while the third

bulb varies from 300μ to 400μ in diameter. The intestine is rectilinear and is slightly dilated at the anterior end. The rectum is short, about 240μ in length, and bears the usual rectal ligaments at its junction with the intestine. The anus is ·35 to ·45 mm. in front of the tip of the tail.

The nerve ring consists of large ganglion cells with large nuclei, and surrounds the first club-shaped bulb of the œsophagus at a distance of 400μ from the anterior end of the body.

The female is stouter than the male, and is 8 mm. long with a maximum diameter of 700μ. Posteriorly it terminates in a short conical tail, ·35 to ·45 mm. in length. There is a pair of small pedunculated papillæ between the anus and the tip of the tail in this species.

The vulva is about 400μ in front of the anus ; the vagina is longer than in *gulosa*, and is 220μ long ; the uterus is single and is full of embryos ; the ovejector is sub-spherical and is broader than long, being 150μ across its greater diameter ; the ovary is elongated, club-shaped, thickly packed with dense protoplasm.

The male has the same general characters as those described for *L. gulosa*. It is 7·25 mm. long with a maximum diameter of 560μ ; the tail varies between 95μ and 150μ in length. The cuticle is slightly expanded round the posterior end to enclose the papillæ. The genital papillæ are of the common type and have the usual disposition of parts. The cuticular barbs found on the anterior lip of the cloaca in *L. gulosa* are absent in this species.

The spicules are equal and similar, about 450μ long, and an accessory piece may be present. The usual dorso-ventral muscles are present as in *L. gulosa*, but are not shown in the diagrams. They are of a similar character as in the type species.

Habitat.—Intestine of *Testudo tabulata*.

Labiduris zschokkei.

Fig. 126.—Anterior end ventral view, head tilted on one side.

Fig. 127.—Head end enlarged, showing the vestibulum, lips and the pectine-bearing processes.

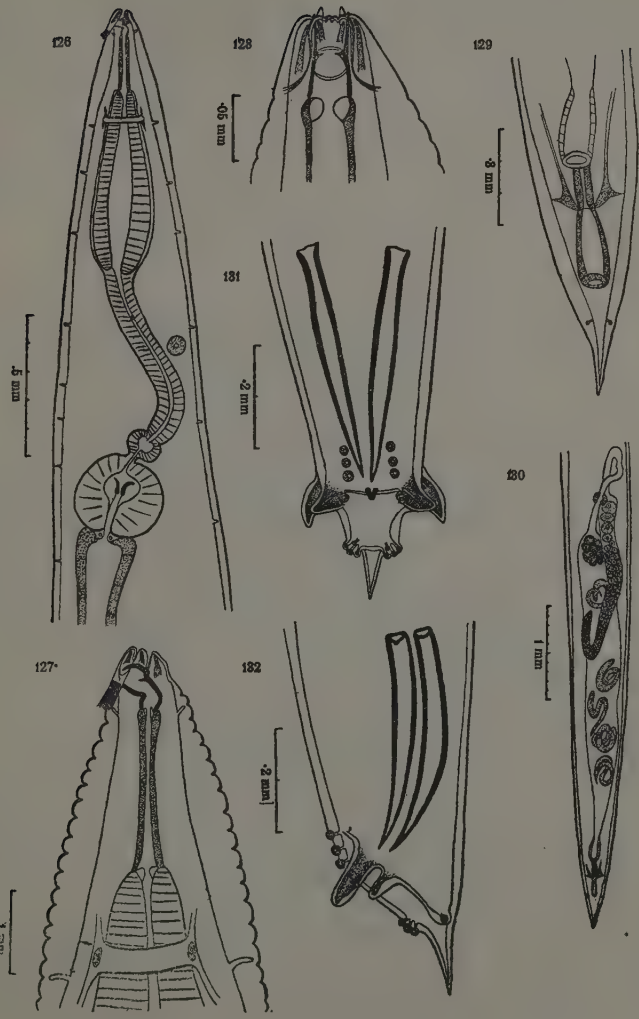
Fig. 128.—Head end, dorsal view.

Fig. 129.—Female tail, ventral view, showing rectal ligaments, etc.

Fig. 130.—Female genitalia, ventral view.

Fig. 131.—Posterior end, male, ventral view, dorso-ventral muscles are omitted.

Fig. 132.—Same, lateral view.


126
.5 mm
128
.05 mm
129
.3 mm
131
.2 mm
130
1 mm
127
1 mm
132
.2 mm

Affinities.—This species resembles *L. gulosa* in general characters and superficial examination may lead one to consider it as the same. Chapin (1924) states it to be a synonym to *L. gulosa* ; but on a closer examination the differences become obvious. The variations in the length of the tail is constant for each species. Besides this character of the length of the tail, the two species can further be distinguished from each other by the relative length of the prepharynx (which is longer in *L. zschokkei*), the position of the excretory pore, the relative distance between the anus and the vulva in the two species, and presence (in *L. gulosa*) and the absence (*L. zschokkei*) of the cuticular barbs on the ventral cloacal lip.

A Note on the Systematic Position of the genus *Labiduris* Schn.

Railliet and Henry (1916) classified the genus *Labiduris* with the genus *Spiroxys*, under a common family characterised thus :—Forms with two equal spicules, and the vulva situated in the middle or behind it.

These two genera, though possessing these two characters in common, are essentially different from each other, primarily in the nature of the œsophagus and therefore cannot be grouped together under the same family. Hence, Travassos (1920) separated the two genera from each other so much so that he grouped one, *Spiroxys*, under *Cucullanidæ*, and the other, *Labiduris*, under *Atractidæ*, and removed both from the superfamily *Oxyuroidæ*. He classed *Labiduris* with *Atractis* on the ground that they both have two bulbs of the œsophagus, have a simple genitalia, and are viviparous.

The present study of the genus, *Labiduris*, reveals the fact that though viviparous, it differs from *Atractis* and its allies. Thus, in the character of the œsophageal bulbs, it has been shown that the genus *Labiduris* has three distinct bulbs, a character quite distinct from all others. Even in the female genitalia this form differs from *Atractidæ* in that it has an ovejector preceding the uterus in its course, while this structure is absent in the family *Atractidæ*. But, perhaps, the most remarkable character is the possession of a vestibulum preceding the prepharynx. This character is unique amongst the *Oxyuridæ*, and is not met with in any other Oxyurid. In this latter character it resembles some members of the group *Spiruridæ*, so that it may be said to form a connecting link between *Oxyuridæ* on one side and *Spiruridæ* on the

other. The characters of the genital papillæ and the lobes round the cloaca are also different. I, therefore, create a new family, *Labiduridæ*, for the reception of the genus *Labiduris*, on the presence of a buccal cavity (vestibulum), triple-bulbed œsophagus, and the presence of an ovejector preceding the uterus, and on the nature of the genital papillæ and lobes in the male.

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Journal of Helminthology, Vol. III., *No.* 3-4, *Aug.*, 1925, *pp.* 151-156.

On *Arthrocephalus gambiensis* n.g., n.sp., a new Ankylostome from an African Mongoose.

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This small ankylostome was collected from the intestine of a Gambian mongoose which had arrived in England some eight months previously, and had died in the gardens of the Zoological Society of London.

The females vary in length from 7 to 9 mm. with a thickness of 0·13 to 0·163 mm., and the males vary from 5 to 6 mm. in length with a breadth of from 0·122 to 0·138 mm. In both sexes the body is slightly attenuated anteriorly and the cephalic extremity is bent dorsally so that the mouth is directed antero-dorsally. Anteriorly the cuticule is indistinctly striated, the striæ, however, becoming more marked towards the posterior end of the body. The cervical papillæ are very small and are situated about 0·05 mm. posterior of the level of the nerve ring.

The buccal capsule is characterised by being composed of a number of cuticular parts articulating with each other. There are six of these. The largest is a complete tube and forms the base of the capsule; it has a shape not unlike a truncated funnel, the truncated edge of which rests on the œsophagus. A single oval plate forms the antero-ventral wall of the capsule. On either side of this plate there are two additional plates, one forming the dorso-lateral and the other the ventro-lateral walls of the capsule. The two ventro-lateral plates do not meet each other along the mid-ventral line, being separated from each other by a V-shaped space. Except for some slight longitudinal ridges, the internal surface of the buccal plates is quite smooth, and the capsule is thus remarkable for the entire absence of buccal lancets, which are present in all the hitherto known ankylostomes. The funnel-shaped basal plate is pierced by the duct of the œsophageal gland, which forms a large and prominent dorsal cone.

The much elongated shape of the buccal capsule resembles that found in members of the genus Dochmoides (= Uncinaria renamed). In a female 7·6 mm. long it was 0·13 mm. and in a male 6 mm. long it was 0·114 mm. deep. The mouth is devoid of any teeth, their place being taken by two thin cuticular plates, one arising from the anterior edge of each of the ventro-lateral plates. When viewed from the dorsal surface the free ventral edges of the ventro-lateral plates may be seen to be bent slightly inwards so that in optical section they may be mistaken for small or rudimentary teeth.

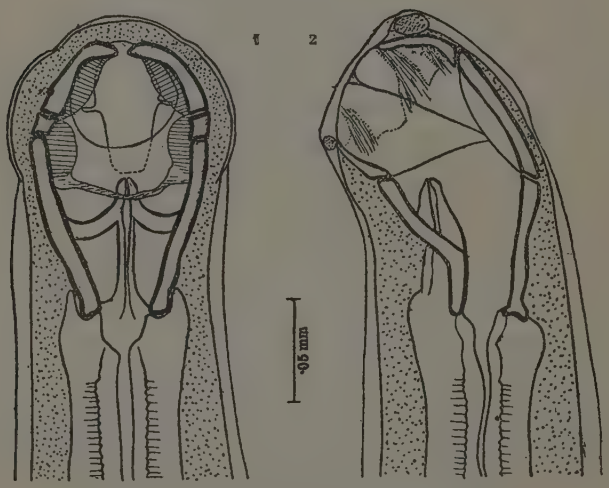

Fig. 1. Dorsal view of cephalic extremity.
Fig. 2. Lateral view of cephalic extremity.

The œsophagus is similar in shape to that found in Ancylostoma, and forms in the female just less than and in the male just more than one-tenth of the total body length. The nerve ring encircles it in both sexes at about the junction of its first and second thirds. The excretory pore is situated between it and the cervical papillæ, and leads into two very large cervical glands extending from 1 to 1·5 mm. posterior of the œsophagus.

The male bursa is typically ankylostome in nature; its shape and rays being very similar to that found in *A. duodenale*, except that the rays are slightly more slender and the medio-lateral and externo-lateral rays do not diverge from each to such an extent as that found in *A. duodenale*. The spicules are equal, thin and filiform and about 0·36 mm. long. A gubernaculum is present; it is 0·065 mm. long by 0·026 mm.

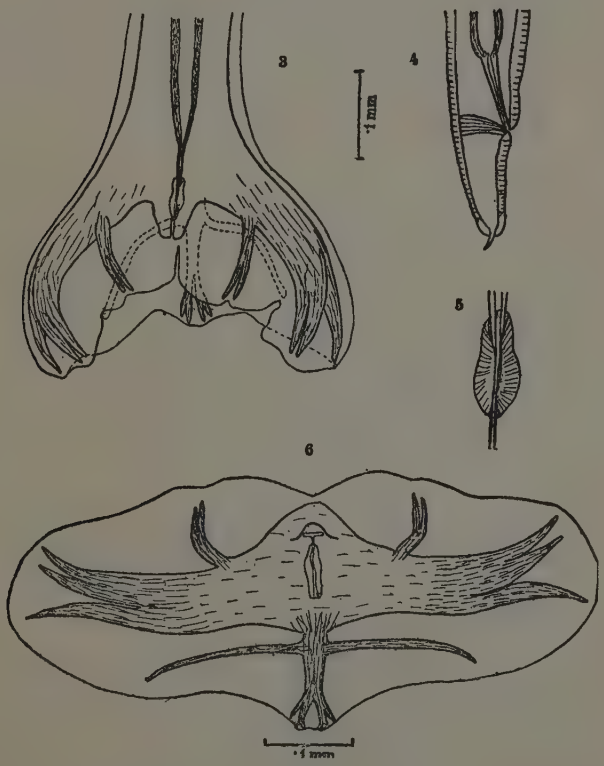

Fig. 3. Ventral view of male bursa.
Fig. 4. Caudal extremity of female.
Fig. 5. Gubernaculum.
Fig. 6. Male bursa extended.

across. It lies in the dorsal wall of the cloaca and has its lateral edges folded inwards so as to embrace the spicules.

The female genitalia take up a longitudinal course along the body, there being no transverse coils of the uteri or ovaries. The vulva is situated at the junction of the second and last body thirds, and is a conspicuous transverse slit with thick cuticular walls. A short vagina leads into the opposed ovejectors which in their turn join the opposed uteri. The eggs are oval and thin shelled and contain about four blastomeres *in utero*; they average about 0·06 mm. long by 0·04 mm. in breadth. The tail is conical and forms nearly one-sixtieth of the body length; it is terminated by a small spike.

Discussion.

A new genus has been created for the reception of the above described species because it showed a combination of characters which together did not agree with those associated with any of the hitherto known genera of ankylostomes. As stated above, the entire absence of buccal lancets is a character distinguishing it from all the known members of Ancylostomidæ. In addition this genus is characterised by possessing a completely articulated buccal capsule, a well developed dorsal cone, no oral teeth, and the female genitalia are arranged longitudinally, without lateral folds.

After comparing the above described species with the descriptions and figures of all the known members of the family Ancylostomidæ, the writer has remained undecided to which member it is most closely allied, and is consequently unable to classify it further.

The articulated nature of the buccal capsule suggests affinities with the genus Bathmostomum, although it must be borne in mind that other members of the Ancylostomidæ show grooves or furrows in the buccal capsule, these perhaps representing a stage in the evolution towards the complete articulation found in the species described above. Bathmostomum, however, is easily distinguished from Arthrocephalus in that the buccal capsule in the former is broader than long and is also provided internally with a number of cuticular ledges.

The elongate nature of the buccal capsule, the disposition of the bursal rays and shape of the bursa suggest affinities with Dochmoides, from which genus it is, however, easily distinguished by the presence of a prominent dorsal cone in addition to the absence of buccal lancets and presence of an articulated buccal capsule.

The writer agrees with Cameron (1924B) that the present stage of our knowledge does not warrant the sub-division of the Ancylostomidæ into sub-families, on the selection of simply arbitrary characters such as the presence or absence of teeth, dorsal cone, etc. Should later investigations definitely show the advisability of retaining the sub-families, then Bunostominæ Looss, 1911, will have to be re-named, because if Cameron (1923) is correct, the correct generic name for the type genus of this sub-family is Monodontus Molin, 1861, not Bunostomum Raill., 1902, and according to the rules of nomenclature the sub-family name must be based on the name of its type genus.

The following *arbitrary* key* is appended in order to facilitate the quick determination of the different genera of Ancylostomidæ.

A. Oral teeth present. Cutting plates absent.
1. Dorsal cone present. Buccal capsule with internal ledges.— BATHMOSTOMUM.
Dorsal cone absent. No internal ledges in buccal capsule.
2. Mouth capsule very small. Adults in fibrous nodules.— GALONCUS.
Mouth capsule well developed. Adults free in intestine.— ANCYLOSTOMA.

B. Oral teeth absent. Cutting plates present.
1. Dorsal cone absent.— DOCHMOIDES.
Dorsal cone present.
2. Buccal lancets absent.— ARTHROCEPHALUS.
Buccal lancets present.
3. Intestinal diverticulum present.— GRAMMOCEPHALUS.
Intestinal diverticulum absent.
4. Dorsal ray asymmetrical.— MONODONTUS.
Dorsal ray symmetrical.
5. Dorsal bursal lobe separate.— GAIGERIA.
Dorsal bursal lobe not separate.
6. Spicule barbed.— NECATOR.
Spicule unbarbed.— BRACHYCLONUS.

C. Oral teeth and Cutting plates absent.— ACHEILOSTOMA.

* The Genus EUMONODONTUS has been omitted because it is at present of little more than theoretical interest.

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Journal of Helminthology, Vol. III, *No.* 3-4, *Aug.*, 1925, *pp.* 157-162.

Viannella viscaciæ n.sp., a Nematode Parasite of the South American rodent *Viscacia viscacia*.

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Introduction.

Two members of a collection of the South American rodent *Viscacia viscacia* received by the Zoological Society of London, died early this year, one of them about 10 days after arrival at the Gardens. At the post-mortem examination both were found to have the alimentary canal heavily parasitized with Trichostrongylid nematodes. In the stomach there occurred *Graphidioides rudicaudatus* and *Trichostrongylus retortæformis*, whilst in the small intestine there were a few specimens of *Trichostrongylus retortæformis* and large numbers of the worm which forms the subject of the present paper. To naked eye examination of the intestinal wall the worms appeared as small bright red spots about the size of a pin's head and it could be seen that each was spirally coiled.

A study of the literature has failed to reveal any member of the Heligmosominæ agreeing in detail with these worms and on that account and because of their undoubted pathogenic action on the host the following description has been prepared.

Morphology.

Specimens were examined alive in normal saline and a good deal of the structure was made out in this way as a specimen would now and then uncoil somewhat and so facilitate microscopic observation. After fixation in hot 70 per cent. alcohol the worms coiled even more tightly than in life. The bright red colour seems to be due to the presence of hæmoglobin or some allied pigment in solution and is confined to the space between the cuticle and the body wall. After fixation the colour goes and numerous irregular concretions of semi-solid material, probably precipitation products from the red fluid, are to be found under-

lying the cuticle obscuring somewhat the various body structures. The *cuticle* is much inflated throughout the whole length of the body and bears numerous longitudinal ridges between which lie fairly deep furrows. The ridges have fine striations which do not extend completely across the furrows. The head end is furnished with a cylindrical inflation of the cuticle forming a *cephalic vesicle* limited behind by a groove encircling the body and situated about ·08 mm. from the anterior end. The cuticle swells out again gradually and at a distance of about ·3 mm. from the anterior end it is traversed on its ventral surface by a deep channel, the *cervical groove*, which extends on to the sides of the body but does not encircle it. Into this groove the *cervical glands* open in the mid-ventral line. These glands have the usual disposition in the body and are filled with fine granules. By careful focussing a large nucleus could be seen towards the posterior end of each. No cervical papillæ were found. The *nerve ring* is situated at about ·25 mm. from the anterior end.

The *mouth* is terminal, elliptical in outline and the mouth cavity is very shallow leading directly to the œsophagus which is about ·45 mm. long and is club shaped. The œsophageo-intestinal valves are small and rounded. The intestine calls for no special description except that mention may here be made of the fact that in all the worms of both sexes examined alive, the intestine was found to harbour a rich infection of actively motile flagellates belonging to the genus Giardia. These were studied by Dr. Thomson, of the Protozoology Department, who has published an account of them (1925). This appears to be the first record of the occurrence of a flagellate infestation of the alimentary canal of a helminth. The writer has on one previous occasion seen an active flagellate swimming freely in the lumen of the intestine of a free living nematode of the genus Diplogaster obtained from rotting celery. It was a solitary organism and at the time the observation was made it appeared reasonable to assume that it was a flagellate from the soil which had been taken in along with bacteria as the worm pumped in its food. In the case of the Giardias in the intestine of *Viannella viscaciæ*, however, the walls of the intestine were thickly carpeted with flagellates which, as Thomson points out, were evidently living and multiplying in that habitat.

Female Characters.

The female is a little longer than the male and measures from 2 to 2·5 mm. in length. The *tail* is very short and conical and owing to the coiling of the worm it is frequently seen to be turned up laterally. The *anus* is a narrow slit just at the base of the tail and the *vulva* is situated about ·05 mm. in front of it. There appears to be no distinct vagina

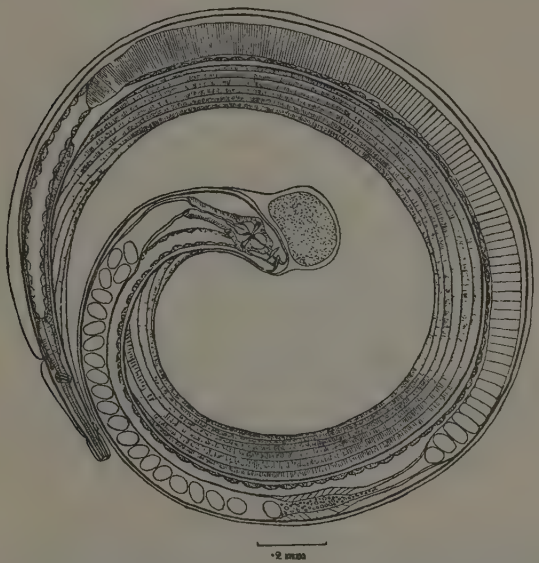

Fig. 1. Female worm drawn under low magnification.

or one so short that the vulva seems to lead immediately to the ovejector apparatus. The latter is a stout muscular structure and is made up of two parts which may be homologised with the *pars ejectrix* and the *pars haustrix* of the paired ovejectors of many other bursate nematodes. The *pars ejectrix* has a very thick muscular wall, is shaped very much like a barrel and is about ·15 mm. in length. Its structure is difficult to make out with anything like precision as the wall is so thick and the spiral twist of the fibres composing it so pronounced that the internal arrangement of its parts is rather obscure even after clearing in lacto-

phenol or in creosote. It can be seen, however, that the lumen is at first narrow and is lined with cuticle. At about the middle of its course, the lining is bunched or twisted like a knot in a skein of wool whilst stretching on either side of this, the lumen extends as a flattened expansion with swollen ends. Anterior to this the lumen widens out and then contracts again at the junction with the *pars haustrix*. The latter is roughly cylindrical in shape, is about ·2 mm. in length when extended and the cuticular lining seems to be longitudinally ridged. The wall is muscular, the fibres composing it having a spiral twist. Anterior to the ovejector is the uterus which has fairly thick walls, is tubular in shape and usually contains from 15 to 20 eggs in various degrees of segmentation. The eggs are from ·068 to ·07 mm. long by ·04 to ·042 mm. wide. There is a rather thick-walled *receptaculum seminis* anterior to the uterus containing a number of rounded spermatozoa and connecting this with the ovary there is a somewhat narrower oviduct. The ovary extends forward in the body as a band of cells, the transverse lines of demarcation between the individual eggs being easily visible. Females which have copulated are furnished with a large, rounded, cement sac-like appendage attached to the posterior region of the body. This is very difficult to dissect away from the living worm without injury to the body but can be removed from preserved specimens fairly easily.

Male Characters.

The males are a little shorter than the females and often appear to be less tightly coiled. For the size of the worm the *bursa* is comparatively large and is shaped like an open bell. The lobes are thick and fleshy and there is no distinct dorsal lobe. When spread out and seen in ventral view the bursa and its rays have a shape and arrangement represented in Fig. 3, which was drawn from a living specimen. It can be seen that the ventral and the lateral groups of rays arise from a broad common base. The ventro-ventral and the ventro-lateral rays are united basally and are confluent throughout the major part of their course as are also the medio-lateral and the postero-lateral rays. The tips of all three lateral rays and those of the externo-dorsal rays reach the edge of the bursa. The externo-dorsal rays are stout, taper to narrow points and arise from the stem of the dorsal ray close to its

base. The dorsal ray bifurcates and each division extends postero-laterally almost to the edge of the bursa and terminates in three rounded points; the outermost one being slightly longer than the other two.

The *spicules* are small and twisted and are generally found lying closely applied to each other. They are from ·16 to ·17 mm. in length,

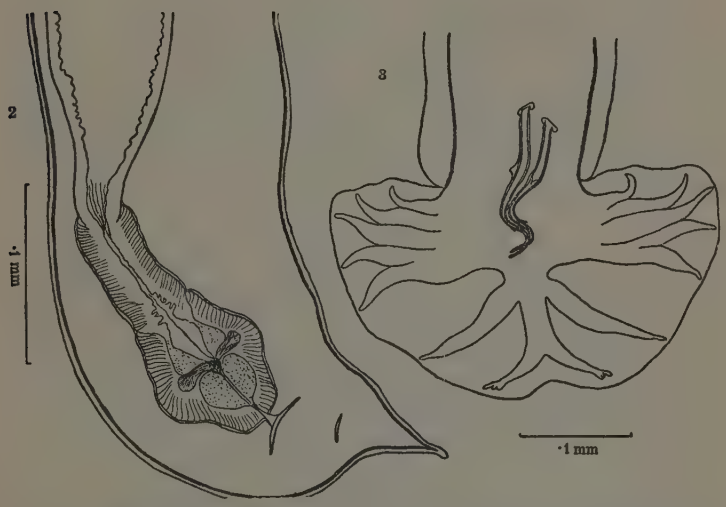

Fig. 2. Posterior end of female showing ovejector apparatus; a composite drawing made up from drawings of three worms, intestine purposely omitted.
Fig. 3. Male bursa and spicules in ventral view.

and their fine points are simple and rounded. Each spicule has its tapering posterior half bent into an S shaped curve whilst the anterior half is straight and lies in the longitudinal axis of the worm. There seems to be a pointed expansion which stands out on each spicule at the level of the commencement of the curvature and extends to another smaller outstanding point where the second curve of the S begins. No gubernaculum was found.

Larval Development.

Female worms which had been kept overnight in normal saline at laboratory temperature showed eggs in the uterus containing almost fully developed embryos. Some of these females were teased up and put in a shallow layer of tap water in a glass capsule which was then placed in a Petri dish containing water to serve as a moist chamber and were left overnight in the incubator at 24° C. On the following day a number of the eggs had hatched and had given rise to typical rhabditiform larvæ with long pointed tails. Each larva was practically ·32 mm. long and had a maximum width of ·017 mm. The buccal rods were ·011 mm. and the œsophagus ·07 mm. long. From anus to tip of the tail was about ·06 mm. and the genital primordium was medianly situated on the ventral side of the intestine. The latter had 8 cells on either side of its lumen.

Systematic Position.

In assigning this worm to the genus Viannella Travassos, 1918, the writer has been guided by the generic diagnoses, descriptions and figures of the members of the two genera Viannaia and Viannella given by Travassos (1921, pp. 65-71). The differences he sets out between them are very slight, the chief point being that in Viannella the ventro-ventral and the ventro-lateral rays are united for at least half their length whilst in Viannaia, these rays are separate to their bases. The worm under consideration therefore agrees with Viannella on this point. The only other difference is that Viannaia is said *not* to have longitudinal striations on the cuticle and, as already stated, the present worm has well marked longitudinal striations, it is accordingly placed under Viannella. On all other points it could equally well be included in the genus Viannaia and the writer is of the opinion that the differences between Viannaia and Viannella as set out by Travassos are so slender as to render it questionable whether they can be considered as of generic value.

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Journal of Helminthology, Vol. III., *No.* 3-4, *Aug.*, 1925, *pp.* 163-166.

The Trichostrongyle Genus *Graphidioides*.

By

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In 1923, the writer in studying some species of the family Trichostrongylidæ, had occasion to create a new genus *Graphidioides*, to receive the form previously known as *Graphidium affine* (Megnin, 1895), Railliet and Henry, 1909. This species differs from the type species of the genus *Graphidium* on the following points: absence of cervical papillæ, shape of bursa and disposition of ventro-ventral rays, shape of accessory piece and spicules, shape of the ovejectors and vagina and posterior extremity of the female. In an addendum on the remaining species of Graphidium, *G. rudicaudatum*, the following statement was made:—

"*Graphidium rudicaudatus*, R. & H., 1909, from *Viscacia viscacia*, from Argentina resembles *G. affinis* very closely. It differs mainly by its smaller size, equal ovejectors, sharply pointed externo-dorsal ray and absence of an accessory piece. Its affinities to *Graphidioides* are so close, that the latter point requires re-investigation. The other points are only of specific value, and it is proposed to include it in this new genus. Should the absence of an accessory piece be confirmed, its position would require re-determination."

Recently the writer has had the opportunity of studying examples of this species which were found in the stomachs of two viscachas (*Viscacia viscacia*), which died in the gardens of the Zoological Society shortly after importation.

Travassos (1921) has published a description of *Graphidium rudicaudatus*, but as the present specimens appear to differ somewhat from those in the possession of Travassos, it has been thought advisable to re-describe this species.

Graphidioides rudicaudatus (Railliet and Henry, 1909).

This species is very closely related to the type of this genus. In the fresh state, specimens are blood-red in colour, but become brown on fixing. The female is 17 to 20 mm. long by ·3 to ·4 mm. wide, while

the male is 10 to 12 mm. long and ·2 mm. wide. Thus while the size of this species overlaps that of *G. affinis*, it is on the whole a smaller form.

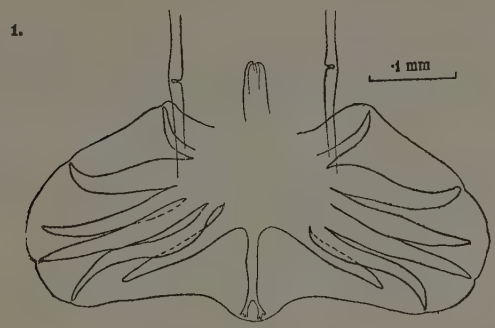
The cephalic extremity and the alimentary system in both species are very similar. The œsophagus is about ·55 mm. long and about ·08 mm. in maximum diameter.

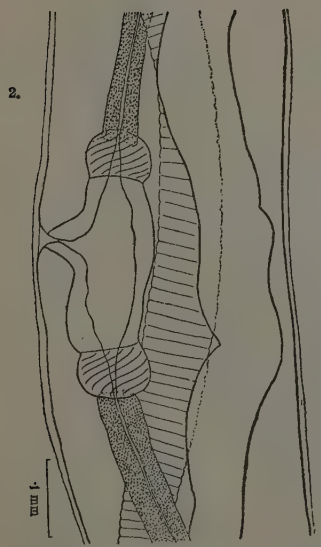
The Female.—The vulva opens in a deep transverse slit and is situated just posterior to the junction of the third and posterior quarters of the body. The body does not narrow immediately behind the vulva. The ovejectors (Fig. 2) are almost, but never quite, equal in length, the superior ovejector being about ·17 mm. long while the inferior is about ·15 mm. Their total length is much smaller than that of *G. affinis*. The conspicuous muscle bands seen near the vulva in that species (Fig. 3), are also present in this. Both ovaries arise in the anterior part of the body. The superior ovary passes posteriorly for a short distance, then turning on itself forms an elongated S-shaped curve before joining the uterus and the ovejector. The inferior ovary arises a short distance behind the origin of the other, but immediately passes to the posterior part of the body where it turns and joins the inferior ovejector. The *pars haustrix* of the ovejector is not sigmoid in the present specimens, but is almost straight. In Travassos' specimens on the other hand, it had a distinct S-shaped curve. The anus is situated about ·35 mm. from the posterior extremity, which does not differ from the type species. The ova are 85μ to 113μ long and 71μ broad. They are typical thin shelled Trichostrongyle eggs.

The Male.—The Bursa (Fig. 1) is very similar to that of *G. affinis*. It is much smaller however in size, although retaining the same proportions. The disposition of the rays is almost identical, but, whereas in *G. affinis*, the externo-lateral and externo-dorsal end bluntly, in *G. rudicaudatus* they are pointed. In both species these rays terminate some distance from the margin of the bursa. The accessory piece is very similar in both, but is rather narrower in this form than in the type species. A transparent cuticular telamon is also visible.

The spicules in this form are only about half the size of those in *G. affinis*, being about 1·5 mm. long. Travassos gives the size of the spicules in his specimens as 1·09 mm. long, while Railliet and Henry in their original description state the size as 1·4 to 1·52 mm. The

spicules are similar in shape to those of *G. affinis*, but the junction between the spicular alæ is much less firm and they are more frequently found apart.





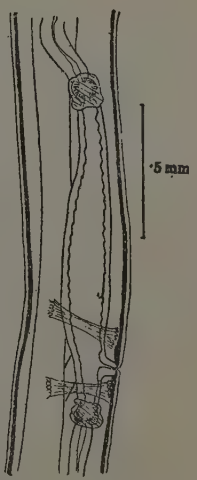


Fig. 1. *Graphidioides rudicaudatus*. Bursa of male.
Fig. 2. *Graphidioides rudicaudatus*. Ovejectors of female.
Fig. 3. *Graphidioides affinis*. Ovejectors of female.

Discussion.

The present form differs from those described by Travassos in several particulars. There are some variations in size, but these may be due to means of preservation and too much value should not be attached to small differences in measurements of these forms. The sigmoid curve of the *pars haustrix* (Vestibule) as seen by Travassos is absent in the writer's specimens. The most important difference however is the presence of an accessory piece. This was not described by Travassos; but as this structure sometimes is very difficult to see, it was probably overlooked. In spite of the differences, the writer has no doubt that he is dealing with the same species as Travassos.

This species is very closely related to *Graphidioides affinis* and there can be little doubt that it belongs to the same genus. The two species differ from each other on the following points:—

	G. affinis.	*G. rudicaudatus.*
(1)	Length of female is 16 to 21 mm.	17 to 20 mm.
(2)	,, male is 9 to 17 mm.	10 to 12 mm.
(3)	Superior ovejector about four times as long as the inferior.	Superior ovejector almost equal to the inferior.
(4)	External dorsal ray, blunt.	Externo-dorsal ray, sharp.

It is not considered desirable at this stage to formulate a detailed and formal generic specification of the genus *Graphidioides*. However, the fact that there are now two species which may be referred to this genus, makes it possible to indicate what to the writer seem to be the more important generic features. These points are the comparatively large size for a Trichostrongyle worm, the unprotected vulva without a posterior thinning of the body, the large size of the ova, the alate pointed spicules in the male, the widely diverging ventral rays, and the termination of the externo-lateral and externo-dorsal rays some distance from the edge of the undivided bursa.

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Journal of Helminthology, Vol. III., *No.* 3-4, *Aug.*, 1925, *pp.* 167-172

Notes on the Helminth Parasites of Domestic Animals in the Aberystwyth Area of Wales.

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Introduction.

The following observations cover the second half of a year's survey of the helminthic parasites of domestic animals in the Aberystwyth area from the beginning of April to the end of September, 1924. The results obtained during the first six months of the survey were published in this Journal in April, 1924 (Vol. II. No. 2).

In general, the work was carried on as previously recorded; material being obtained by the examination of the intestinal contents of cattle, sheep and pigs slaughtered at the Aberystwyth abattoir; observations were also made upon the occurrence of parasites not found in the alimentary canal. With the advent of the 1924 crop of lambs from the end of April onwards, it was found to be impossible to devote much time to other hosts; the heavy infections with *Moniezia spp.* which usually occur in lambs at that time of the year, greatly increased the work and allowed but little time for investigations on parasites in other animals. The following notes therefore refer chiefly to lambs and to older sheep although the number of the latter that could be obtained for examination during the summer months was small. A record was also kept of the farm on which each host had been reared and although this information might not always be reliable a considerable amount of data was obtained which may be useful in further investigations on helminthic parasites.

The writer desires to acknowledge his indebtedness to Prof. R. T. Leiper, F.R.S., and Prof. R. D. Laurie for helpful advice and encouragement in the work.

Technique.

The intestinal contents of each host were examined for worms by the simple process of sedimenting several times with water, the residue being then poured in small quantities at a time into a large photographic developing dish. The worms could then be easily picked out and identified. Only the larger species were counted, the smaller species, chiefly Trichostrongyles, being usually present in such large numbers that the time required in counting them would hardly be justified. Trials were made with a nest of sieves as described by Cameron (1923) for separating out the worms but it was found that this method did not diminish the work particularly in the examination of the intestinal contents of each individual host. Added to this is the frequent overflowing of the sieves due to clogging with the resultant loss of worms and also the difficulty of getting the smaller worms free from the fine mesh. This latter method is no doubt chiefly useful in working through large quantities of material from several hosts in order to get a good number of certain species.

Observations on Species.

Fasciola hepatica.—Specimens of this species were obtained at various times throughout the summer months whenever old sheep were slaughtered. A few instances of its occurrence in lambs were observed.

Moniezia spp.—No attempt was made to identify the different species of this genus found in the district, but the number of individuals present in each host was counted. Heaviest infections were found during May; one lamb containing 336 tapeworms at various stages of growth. The following figures give the percentage of lambs infected for each month together with the average number of tapeworms present.

	May.	June.	July.	Aug.	Sept.
Percentage infected ...	76·9	53·9	48·0	63·6	74·3
Average per host ...	83	37	10	5	4

No figures are given for April owing to the small number of lambs examined; tapeworms are, however, known to be exceedingly common in this month.

The above figures show that while the parasite is most common in May there is a distinct drop in the percentage infected in mid-summer with a rise again in August and September. The average number of worms in each shows a steady decline throughout the summer months, a feature which may be due to increasing immunity in lambs as they get older. It is more difficult, however, to explain the rise in the percentage of lambs infected during August and September and figures obtained from only one season's work, do not allow definite conclusions to be drawn. A similar periodicity in the occurrence of the intermediate host, assuming that such exist, may account for this.

An examination of the contents of the first stomach of lambs in order to find out what animals might be picked up in grazing, was not attended with much success. The large amount of material in the first stomach made this work long and laborious. A few insects and arachnids, belonging to the following groups, were found :—Ground beetles, Rove beetles, Dung beetles, Weevils, Ants, Aphids, Plant bugs, Ticks and Mites.

A close scrutiny of the contents of the small intestine of lambs heavily infected with young adult tapeworms did not yield any specimens in the bladder-worm stage. Very young adults were obtained throughout the period but no trace of larval structures. The smallest tapeworm found, measured ·43 mm. in length and was obtained late in September.

Cysticercus tenuicollis.—This species, although common in old sheep, particularly in Spring, was not observed in lambs until July, and from that time onward its occurrence was infrequent.

Monodontus trigonocephalus.—The occurrence of this species during the period under investigation presents interesting points in relation to the age of its host. It was found to be exceedingly common in adult sheep throughout the summer months and in many cases this was the only intestinal worm present. In lambs, however, none were observed during April and May, and it was not until the end of June that young adults were first found. These immature forms of *M. trigonocephalus* were obtained up to the end of September and probably appear afterwards.

The following figures shew the increase in the percentage of lambs infected, together with the average number in each host.

	May.	June.	July.	Aug.	Sept.
Percentage infected ...	—	23·1	36·0	59·9	91·4
Average per host ...	—	3	7	8	11

It would seem that either the lambs are somewhat immune to *M. trigonocephalus* or that the conditions during spring and early summer are not favourable for its development. Older sheep are abundantly infected throughout the year so that there is always an ample source for infection assuming of course that eggs are passed all the year round.

Trichuris ovis was found in lambs in April and persisted throughout in fair numbers.

Oe. venulosum and *Chabertia ovina*.—These two species were found from May onwards, increasing somewhat in number as time went on. Young adults and 4th stage larvæ were found in each case. Observations on *C. ovina* did not confirm those of other workers (Ransom, 1911) as to the comparative harmlessness of this species. Individuals were frequently found attached to the inner lining of the large intestine and a petechial condition of the gut was often seen to coincide with heavy infections by this species. In one case where 308 individuals were found the host was observed to be in a very poor condition.

Hæmonchus contortus was comparatively rare during Spring and early summer but increased in August and September. One lamb which had been reared on the mountains and fed off for two months on low lying pastures near the coast was found to contain well over 350 specimens of this worm in varying stages of growth. This seems to indicate that infection was obtained at the latter feeding ground.

Ostertagia circumcincta was one of the most common species, occurring in both sheep and lambs throughout the year, and was more commonly met with during Spring and early summer than *Nematodirus filicollis*.

Trichostrongylus vitrinus, *Cooperia oncophora* and *C. curticei* occurred quite frequently throughout.

The following species, not previously recorded for this survey were also found.

Echinococcus granulosus was found several times in sheep and pigs.

Dictyocaulus filaria occurred quite frequently in lambs throughout the summer.

Ostertagia trifurcata and *Strongyloides papillosus* were only obtained in small numbers.

Capillaria sp.—One female belonging to this genus was found in the ox but its identity with *C. bovis* (Schnyder, 1906), Ransom, 1911, cannot be made out owing to the insufficient description given. The measurements of this specimen are as follows :—Length, 16·5 mm., breadth at base of œsophagus ·057 mm., breadth at posterior end ·02 mm. Eggs ·47 to ·50 mm. long by ·022 mm. wide. These correspond fairly closely with the measurements given by Schnyder for *C. bovis* and might also apply to *C. longipes*, differing from the latter chiefly in that the length is somewhat less and the posterior end narrower. Further work is necessary, however, to ascertain the validity of these two species.

General Remarks.

The difference between lambs and sheep both in the number and in the species of helminths they contained, was well marked during the investigation. Lambs invariably harboured large numbers of most of the common species recorded in the district for this host with the exception of *M. trigonocephalus*, which was not found in Spring and early Summer ; sheep, from a year old onwards, on the other hand, were comparatively free from intestinal worms, the exception again being *M. trigonocephalus* which was rarely absent. It would therefore appear that age of host is an important factor in determining the occurrence of helminths in animals and should be taken account of in seasonal variations in frequency.

An interesting fact noted during the survey was the large number of intestinal parasites which lambs harboured and yet be in a sufficiently

good condition to be slaughtered for food purposes. A lamb examined in August contained the following worms :—12 *Moniezia spp.*, 17 *M. trigonocephalus*, 79 *T. ovis*, 17 *Oe. venulosum*, 22 *C. ovina* and fairly heavy infections of *O. circumcincta*, *T. vitrinus*, *N. filicollis*, *C. oncophora* and *C. curticei*. This case was by no means exceptional, and showed no indication of a low condition when slaughtered. A large number of observations were made on carcases in the abattoir but no definite relation was found between the amount of fat present and the number of helminths the host contained. A very heavy infection. particularly with one or two species was often associated with a low condition and the animal " killed dry " to use a butchers' phrase. This however was not invariably the case even with lambs which had been feeding on the same pastures. The helminthic infection of the lamb given above might be contrasted with that of a two year old wether which had been fed on the same pasture and slaughtered on the same day. The latter contained none of the larger species of worms a fair number of *O. circumcincta* and *T. vitrinus* only being present. It would seem probable that lambs are exceedingly liable to heavy infections but tend to become immune as they get older and also to lose the greater part of the worms picked up during their first summer. With the growing tendency among farmers in this country in favour of early maturity in stock the question of helminthic infection in young food animals is exceedingly important and although the majority of worms rarely cause death the loss to Agriculture by retarding growth and prolonging the fattening period of the host must be considerable.

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Journal of Helminthology, Vol. III., *No.* 3-4, *Aug.*, 1925, *pp.* 173-176.

Skin Penetration by the Infective Larvæ of *Dochmoides stenocephala.*

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Introduction.

That the infective larvæ of a number of species of hookworm are capable of penetrating intact skin has been demonstrated in the following, *Ancylostoma duodenale, A. caninum, A. braziliense* and *Necator americanus.*

So far as the writer is aware, however, it has not been shown that the mature ensheathed larvæ of another common hookworm that of the dog and fox, namely, *Dochmoides stenocephala,* are skin penetrators. An opportunity for determining this was therefore taken and the necessary experiment was carried out by means of the writer's floating raft method.

Material.

A dog accidentally killed at Aberystwyth was examined very soon after death by Mr. E. Aneurin Lewis, B.Sc., Field Officer of this Institute, and found to contain 16 adult *Dochmoides stenocephala,* no other worms being present. The rectal contents were dispatched to the writer who made them into a Petri dish culture with the addition of a small quantity of animal charcoal. The culture was incubated at 24° C., and after 8 days the moist blotting paper in the lid of the dish and also the surface of the culture were washed with distilled water and the washings concentrated by centrifuging. In this way about 40 ensheathed larvæ were obtained.

The early development of the larvæ was not followed, as the method of culture with animal charcoal did not lend itself to this, and moreover it was worked out many years ago by Leuckart. At all events Looss (1911, p. 345 *et seq.*) freely quotes Leuckart on the structure of the first

stage larva of *Uncinaria criniformis* and this species is, in the opinion of both Fülleborn (1924) and Cameron (1924), identical with *stenocephala* which the latter author has placed in the genus Dochmoides.

Morphology of Ensheathed Larva.

The mature larva has the usual structure of ensheathed third stage hookworm larvæ. It varies in length from ·7 to ·8 mm. and has a maximum breadth of ·035 mm. The sheath is noticeably stout and the larva fills it out well when alive but on fixation in 70 per cent. alcohol contracts considerably within it. The œsophagus is about ·16 mm. long, whilst the intestine has a length of ·27 mm., and its walls are made up of 32 sharply defined cells. The genital primordium is situated ventrally to the intestine a little posterior to the middle of its length.

Biology.

Behaviour in weak anilin stain.—Four or five ensheathed larvæ were placed in a small drop of water on a slide and a drop of 1 per cent. Thionin blue solution was added and a coverslip placed on the preparation. The larvæ became very active and as the coverslip pressed more and more with the evaporation of the liquid, a careful watch was made to see if any of the larvæ would break out from their sheaths but none of them did so. In this they differed from the ensheathed larvæ of *Ancylostoma duodenale* and *Necator americanus*.

Skin Penetration.—A preparation was made to test this by using a portion of shaved abdominal skin of a mouse stretched on a cork raft by the writer's usual method (Goodey, 1922 and 1925). The raft was floated on normal saline at 37° C. in a glass jar and on the surface of the shaved area a drop of water containing about thirty larvæ was placed. The drop gradually evaporated and the larvæ were observed under the microscope. They moved rapidly in all directions and were seen frequently with head ends pressing out against the edge of the drop; many of them at times passing out beyond the original limits of the drop. None of them, however, were seen to leave their sheaths and penetrate the underlying skin and when the surface of the skin seemed to the naked eye to be dry they could still be seen moving over the surface in a very thin film of moisture.

In order to give them every opportunity to penetrate the skin a drop of distilled water was placed on the skin where the first drop had been and the glass jar containing the preparation was put into the 37° C. incubator at about 6 p.m. and left there overnight. In the morning it was taken out and the surface was seen to have become quite dry. A drop of water was again put on the surface and then sucked up again in a clean pipette and the same process was repeated so as to take off any larvæ which had remained on the skin. The washings were put into a shallow glass capsule and then examined under the microscope, when it was found that there were several empty sheaths and many actively motile larvæ. The latter are evidently capable of resisting desiccation for some hours as they had been in the incubator overnight and when first examined the surface of the skin was quite dry. Revival was also quite rapid as the larvæ were swimming freely within 10 to 15 minutes of re-moistening the skin. The power of resisting desiccation on a glass slide was not actually determined but the fact that the larvæ revived after being on the skin for several hours at 37° C. shows that they can resist drying to a much greater extent than the ensheathed larvæ of *Ancylostoma duodenale* and *Necator americanus*, which are very rapidly put out of action by desiccation, and have never revived when re-moistened after being left overnight on a skin surface at 37° C.

The skin on the cork raft was fixed in hot 70 per cent. alcohol and set aside for later clearing and examination.

The saline in the jar was next dealt with and was first examined under the low power of the binocular microscope by means of which it was possible to examine the stratum of liquid at the bottom of the jar. It was then seen that there were 4 or 5 active larvæ moving about in this region. These were carefully pipetted up in a clean pipette and placed in another glass capsule for examination under higher magnification when it was found that all except one were still ensheathed and had evidently passed through the skin in that condition. Both lots of larvæ, *i.e.*, those removed from the surface of the skin and those taken from the saline at the bottom of the jar were then fixed in hot 70 per cent. alcohol and afterwards transferred to 70 per cent. alcohol plus 5 per cent. glycerine for final mounting in glycerine.

The skin was taken up to 95 per cent. alcohol, then to creosote and mounted in Canada balsam between two large coverslips so that both sides could be examined under the high power of the microscope. It was found to contain a few larvæ well embedded in the skin and all in an ensheathed condition. This was not surprising seeing that four out of the five larvæ which had passed through the skin and were recovered from the saline were still ensheathed.

This result appears to the writer as very interesting and well worthy of note as being rather different from the phenomena of skin penetration in the case of *A. duodenale* and *N. americanus*, where one usually finds that the larvæ first leave their sheaths and then enter the skin or emerge from their sheaths in the act of entering; the empty sheaths being left behind with the open ends held beneath epidermal scales. It resembles that found in the case of *Trichostrongylus orientalis* by Kitamura (1916, p. 48 *et seq.*) who investigated the life-history of this human parasite and found that the majority of the ensheathed infective larvæ entered the skin of an experimental mouse whilst still in an ensheathed condition.

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Journal of Helminthology, Vol. III., *No.* 5, *December*, 1925, *pp.* 177-184.

On Two Nematode Parasites from the Gizzard of Pea-fowls.

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Acuaria (Cheilospirura) pavonis n. sp.

The material on which the following description is based consists of a single pair of male and female worms obtained from under the gizzard lining of a Burmeese Pea-fowl (*Pavo muticus*). Although the material was so limited, the parasites are of sufficient interest to warrant their description, especially as they show characters which lead one to the conclusion that they represent a hitherto unknown species; also it is a species very closely related to *A.* (*Cheilospirura*) *hamulosus*, a parasite of chickens.

Morphology. The anterior end of the body is terminated by two lateral and triangular lips, the apex of each bearing a large blunt tooth. No external lip papillæ were noted. The cuticle is coarsely striated and in addition shows four pairs of longitudinal thickenings (cordons), two pairs ventro-lateral and two pairs dorso-lateral in position; these thickenings originate one pair from the dorsal and ventral angles of each lip. In the female the dorso-lateral cordons extend slightly posterior of the level of the vulva, whereas the ventro-lateral ones terminate at the level of the vulva. In the male the cordons extend down the body for 4·8 mm. From about the level of the posterior end of the muscular œsophagus these cordons in their backward extensions become corrugated so that they appear to be built up of a series of elongate bosses placed irregularly one behind the other.

The mouth leads into an elongate pharynx (Fig. 1), whose cuticularised wall shows a transverse striation. In the female the pharynx is 0·305 mm. long and 0·06 mm. broad, and in the male it is 0·157 mm. long by

0·03 mm. broad. The œsophagus which follows it is long and is composed of an anterior muscular portion and a posterior glandular portion. These portions are respectively 1·138 mm. and 3·25 mm. long in the female, and 0·654 mm. and 1·38 mm. long in the male. In both sexes the whole organ thus occupies about 1/3·2 part of the body. The nerve ring encircles the muscular œsophageal part towards its anterior end, and it is situated about midway between the level of the anterior termination of the œsophagus and the level of the excretory pore, which in the male is 0·315 mm. from the anterior end of the body.

Female. The female is 14·7 mm. long with a maximum thickness of 0·358 mm. in the middle of the body. The body is slightly attenuated anteriorly and more so posteriorly where it is terminated by a somewhat pointed tail 0·407 mm. in length (Fig. 2).

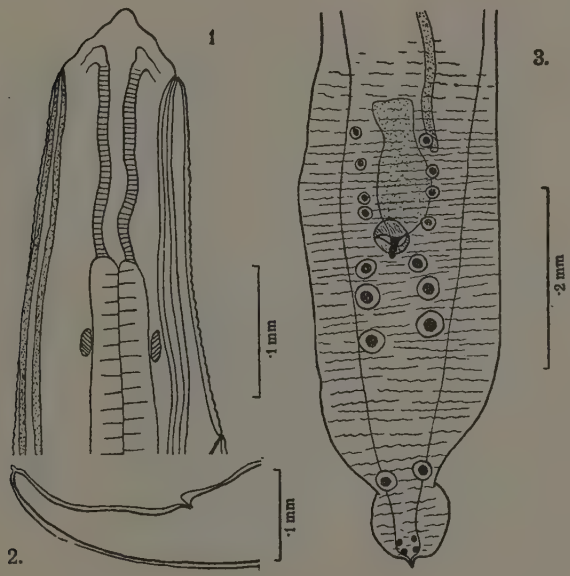
The vulva lies flush with the body surface and is situated 8·4 mm. from the anterior end, its position thus dividing the body into the ratio of nearly 3 : 2. The vulva leads into a long and muscular vagina which first passes backwards and then forwards and then backwards again to the level of the vulva where it joins on to the two connecting tubules of the two divergent uteri. No mature eggs were present *in utero*.

Male. The male is much smaller than the female, measuring 6·5 mm. in length with a maximum thickness of 0·18 mm. The posterior end of body is coiled slightly ventral-wards, and carries two well-developed caudal alæ (Fig. 3); across these alæ, and across the ventral surface of the body between them, there are numerous irregular and transverse ridges. The caudal papillæ consist of four pre-anal and six post-anal pairs. Of the post-anal papillæ three pairs are large and situated in two longitudinal rows immediately behind the cloaca; the last two pairs are small and are situated towards the tip of the tail; the remaining pair is large and is found at the junction of the third and last quarters of the tail.

The spicules are markedly unequal and dissimilar; the left is long and terminates in a chisel-like tip; it is 1·56 mm. long and 0·016 mm. thick; the right is short and broad and 0·215 mm. long. A gubernaculum is absent.

Types to be deposited in the British Museum (Natural History).

Affinities. The shape of the lips and the length and configuration of the cordons closely ally this species to *Acuaria* (*Cheilospirura*) *hamulosus* (Dies., 1851); it differs from this species, however, in that the cordons do not extend to the posterior end of the body, and in that the arrangement and number of the post-anal papillæ is different;



Acuaria (*cheilospirura*) *pavonis* n. sp.
Fig. 1.—Anterior portion of body.
Fig. 2.—Tail of female.
Fig. 3.—Tail of male, ventral view.

this latter species, according to Drasche (1884), possesses only four pairs of post-anal papillæ.

CYRNEA BULBOSA (v. Linst., 1906) Ortlepp 1922.

Syn. *Physaloptera bulbosa* v. Linst., 1906.

The material available for study consisted of three batches, one of which was collected from under the gizzard lining of the common Peafowl, *Pavo cristatus*, and the rest from the same position in two Burmeese Pea-fowls, *Pavo muticus*.

Morphology. The anterior extremity (Fig. 4) is rounded and the mouth is bounded by two lateral lips each of which is subdivided into a large median lobe and two smaller lateral lobes ; they are unarmed.

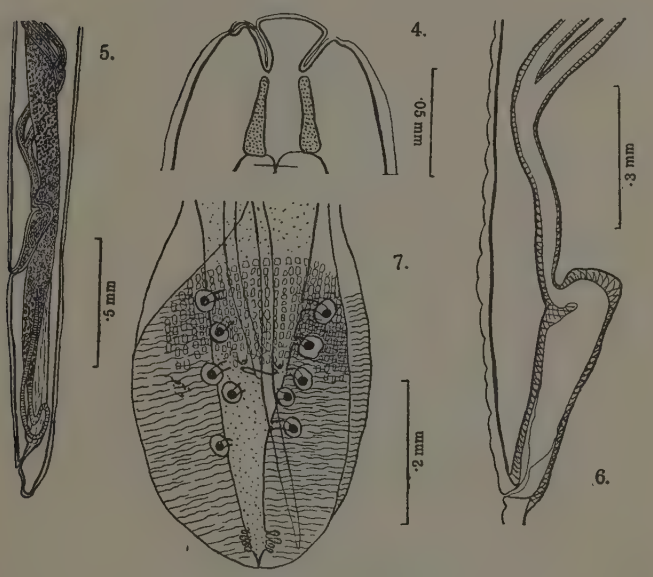
The cuticle has a smooth appearance but on examination under high magnification a very delicate transverse striation becomes visible. The cervical papillæ are small and spike-like and are situated just anterior of or at the level of the nerve ring. The excretory pore opens to the exterior just posterior of the nerve ring.

The mouth leads into a well developed and tubular mouth capsule whose depth is about one and a half times its breadth ; its wall is strongly cuticularised and gradually thickens towards its posterior edge. The œsophagus is long and straight and is composed of two parts, an anterior short and slightly thinner muscular portion and a posterior portion which is glandular. The anterior portion in both sexes is about 1/10th of the total length of the œsophagus, and the nerve ring encircles it in its posterior third. The whole œsophagus forms in the female just more than, and in the male just less than, 1/10th of the total length.

Female. The females are long and slender, and measure up to 24 mm. in length with a maximum thickness of 0·455 mm. in their middle ; they are only slightly attenuated anteriorly, and posteriorly the body maintains a more or less uniform thickness up to the anus after which the body tapers quickly to form the short and somewhat conical tail, which forms about 1/129th part of the total body length (Fig. 5).

The vulva opens towards the posterior extremity of the body about 1·25 mm. from the tip of the tail ; its position divides the body roughly into the proportion of 18 : 1. It leads into a thick-walled and muscular vaginal chamber which increases in diameter anteriorly ; it is packed with

eggs and in the longest female measured 0·546 mm. long by 0·137 mm. broad at its base (Fig. 6). A thick-walled ovejector, 0·59 mm. long in the same female, arises laterally from the base of the vagina; anteriorly it divides into the two uteri which pass forwards more or less parallel to each other; their most anterior limit is at about the level of the middle



Cyrnea bulbosa.
Fig. 4.—Anterior extremity of body.
Fig. 5.—Posterior portion of body of female.
Fig. 6.—Terminal portion of female genitalia.
Fig. 7.—Tail of male, ventral view.

of the œsophagus, from where they recurve and pass backwards beyond the vulva to join the ovaries which extend almost to the posterior end

of the body. The eggs are small, oval and thick-walled, and in the vaginal chamber have already embryonated; their dimensions are 0·042 mm. long by 0·024 mm. broad.

Male. The male has a body very similar to that of the female except that it is smaller and the posterior extremity is bent ventral-wards and is provided with two well developed caudal expansions; they vary in length up to 10·4 mm. with a maximum thickness of 0·325 mm. The caudal "bursa" (Fig. 7) is oval and its anterior lateral margins are rolled inwards; each expansion is traversed internally by numerous wavy and transverse muscle bands, thus giving the caudal alæ a striated appearance. The ventral surface of the body immediately anterior to the cloaca is covered by irregularly arranged tubercles. There are three pairs of shortly pedunculated pre-cloacal papillæ; behind the cloaca there are two further pairs of pedunculated papillæ, of which the first pair is more ventral in position and is provided with shorter stalks; at the tip of the tail there are also present four pairs of small papillæ bunched close together in two lateral rows; the last pair of these is small and not always easy to see.

The spicules are long, tubular and unequal, that of the right being the shorter and ending in an obtuse point; its length is 0·945 mm., whereas the left is 2·45 mm. long and terminates in a sharp point. An accessory piece is present; it has the shape of a median body provided with lateral wings; the body lies along the dorsal aspect of the spicules while the wings pass forwards round the spicules, one on either side.

Discussion. From the above description it is easily seen that this parasite does not belong to the genus Physaloptera. It has been placed in the genus Cyrnea because of the nature of its male and female genitalia and also because of its habitat. It does not agree with the definition of this genus as given by Seurat in that it possesses two tri-lobed lips instead of two lateral and one dorsal and one ventral lip.

Von Linstow describes this species from material collected from the ventriculus of *Pavo specifer*. The description given above differs in some respects from that given by v. Linstow, *e.g.*, the males and females seen by him are larger, measuring respectively 18·4 mm. and 27·8 mm. in length. The vulva in the writer's material was slightly more anterior

than in v. Linstow's, in which its position divided the body into the ratio of 45 : 2. With regard to the male, v. Linstow states that the third pair of caudal papillæ is unstalked and is ventral in position, whereas in the writer's material all the papillæ are stalked and the fourth pair is ventral in position. The lengths of the spicules are also slightly different, those given by v. Linstow being 0·88 mm. and 2·17 mm. for the right and left spicules respectively. Notwithstanding these differences, which at most are not very important and may be due to errors of observation, the writer has no hesitation in placing his material in v. Linstow's species.

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Journal of Helminthology, Vol. III., *No.* 5, *December*, 1925, *pp.* 185-192

Investigations on Eelworm in Potatoes in South Lincolnshire

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The failure of the potato crop on some fields in South Lincolnshire has been noted for several years. The stunted growth of the plant, together with the wilting and yellowing of the foliage, usually associated with root trouble, were the symptoms observed, while the yield suffered greatly owing to the small size of the tubers formed. In a few instances the crop over the whole field was so poor that the yield hardly paid for the seed planted ; others shewed bad patches which seemed to increase in size year after year.

This failure of the crops had been attributed to various fungoid pests which had been found on the plants examined, and it was not until 1924 that the finding of large numbers of cysts of *Heterodera schachtii* on the roots drew attention to this eelworm as a possible cause of the trouble. Early and second early varieties of potatoes seemed to suffer most, and although cysts were found in abundance on the roots of late varieties very little damage to the plant could be observed, while there was no diminution in yield recorded. A further knowledge of the extent of damage done by *H. schachtii* and of control measures seemed highly important, since a further spread of this pest might mean the placing of some of the finest potato soils in this country under less profitable crops. The present investigation was commenced in October, 1924, laboratory facilities being obtained by the courtesy of the Holland County Council at the Kirton Agricultural Institute, while the Institute Farm, situated within easy reach of the laboratory, made a suitable centre for field work.

The season was too far advanced when the work was started to make many observations on the growing plants, the early and second early

varieties having already been lifted as well as a large portion of the main crop. Attention was therefore chiefly directed to the winter cysts of *H. schachtii* in the soil, while notes were made on methods of cultivation, rotation of crops, manuring and type of soil prevalent in the district.

The plots of potatoes under manurial and variety trials on the Institute Farm seemed a convenient starting point where some indications might be obtained of the effect of different manures on this eelworm and also of the susceptibility of different varieties. It was therefore necessary to find out some simple means of obtaining the number of cysts present in a sample of soil so that comparisons between plots could be made.

Technique.

The ordinary method of working through a sample of soil and picking out the cysts was too long and tedious and, moreover, far from accurate as cysts were easily overlooked in this way. It was found that by shaking up a small quantity of soil with water, the cysts floated easily to the surface and could be counted with more accuracy.

The following method, which has since been modified, was therefore adopted for greater convenience in counting :—

Samples of soil were taken in the field to a depth of 8 inches by means of a soil sampler, this depth representing the normal depth of cultivation. The soil was then air-dried and rubbed down in a mortar and 20 cc. of the fine soil remaining on the 1/60th-inch mesh was taken as the portion for estimating the number of cysts present. This latter sample was placed in a narrow-necked flask, which was then half filled with water, and after shaking for a short time more water was added until the flask was almost full, and then allowed to stand. The cysts and organic matter which floated to the surface were then poured off on to a filter paper which had been placed over a small sieve, a sharp turn of the flask whilst pouring off causing all the cysts to be washed down without the danger of any clinging to the sides. This latter difficulty in pouring off all the cysts with as small a quantity of water as possible, necessitated the use of a flask with a long narrow neck of about 1,000 c.c. capacity.

Over a thousand samples of soil were taken from plots under manurial and variety trials, and cysts were counted as described above. The

figures thus obtained were plotted out on a plan of the field under the trials.

Owing possibly to the uneven distribution of the cysts when samples of soil are taken immediately after the potatoes are lifted and before the soil has undergone further cultivation, the figures obtained varied greatly and did not shew any indications of the possible effect of different types and quantities of artificial manures. Even in the case of Potash, which has always been recommended against eelworms, no significant difference was obtained in the number of cysts from a plot which had received no Potash than from one which had a dressing at the rate of 2 cwts. per acre. It is probable, however, that assuming Potash to have some effect on the eelworm, the dressing of 2 cwts. per acre was too small to shew any appreciable effect. It is further possible that the error in sampling is too large to shew the increase in the number of cysts during one season.

The figures obtained from the plots under variety trials shewed a steady decline from one side of the field to the other and merging into a corner which contained hardly any cysts. This feature, while it deprived one of the possibility of making comparisons between varieties, shewed that there was some degree of accuracy in the method of sampling.

Field Experiments.

Through the good offices of Mr. Wallace, Principal of the Kirton Agricultural Institute, field experiments were laid down to test the effect of various chemicals on eelworm and also the susceptibility of several early varieties of potatoes to this pest. An acre of land was obtained for the trials on a field where the potato crop had been almost a complete failure in 1924. Eclipse had been planted and only yielded from 2 to 3 tons of potatoes, which is only equal to about a third of a normal crop. The trouble had been put down to eelworm, and cysts were certainly very abundant in the soil and on the roots of plants.

The field had been under arable cultivation for about 12 years, the potato crop being the one chiefly grown during that time and some excellent yields had been obtained. The suggestion that lack of drainage might be the cause of the failure resulted in an elaborate system of drains being laid down by the owners in the autumn of 1924,

but this had apparently no effect since the portion of the field under potatoes this year gave an equally poor yield.

The soil might be described as a fine sandy loam, being typical of the soils found in South Lincolnshire and eminently suitable for growing early potatoes. The following is a chemical analysis of the soil from this field which shews it to be about the same as the average for the soils in the district :—

Loss of moisture ...	2·6%	Total Potash ...	·136%
Loss on ignition ...	6·1%	Available Potash ...	·0176%
Nitrogen	·291%	Total Phosphates ...	·361%
$CaCO_3$	·1755	Citric soluble Phosphates	·0727%

Lime requirement, 3 cwts. per acre.

This analysis shows that there was no deficiency in essential plant food which might account for the failure of the potatoes, in fact the whole field, with the exception of one acre under trials as already mentioned, was under mangel for seed and produced one of the best crops seen in the district. It might also be of interest to note here that no eelworm cysts have been found on the roots of the mangel in this field.

The plots laid out on an acre of the above field were arranged in two series; (1) to test the effect of various chemicals, and (2) to test the susceptibility to eelworm of a number of early varieties of potatoes. A duplicate of each plot was also planted. The plots in the first experiment consisted of four rows, and each plot, together with its duplicate, had a area of ·062 of an acre. Those in the second experiment consisted of 3 rows with an area of ·046 of an acre.

A basal dressing of artificial manures at the rate of 10 cwts. per acre was added to all the plots and was made up in the following proportions :— $3\frac{1}{2}$ cwts. Sulphate of Ammonia, 4 cwts. Superphosphate, 1 cwt. Steam Bone Flour, and $1\frac{1}{2}$ cwts. Muriate of Potash. This compound manure is considered suitable for early potatoes on South Lincolnshire soil. In the first series of experiments the following chemicals were added on different plots :—

Bleaching Powder,	at the rate of	2 ozs.	per sq. yd.
Sulphur	,, ,,	2	,, ,,
Ground Limestone	,, ,,	32 cwts.	per acre.
Muriate of Potash	,, ,,	5	,, ,,
		(This includes the amount in the basal dressing.)	
Sodium Chloride	,, ,,	10 cwts.	per acre.
Nitrolim	,, ,,	3½	,, ,,
		(This replaced the Sulphate of Ammonia in the basal dressing.)	
Naphthalene	,, ,,	2 ozs.	per sq. yd.

All these plots were planted with Midlothian, together with a control plot with a basal dressing only.

The second series of plots was planted with the following varieties together with a basal dressing of manure: "Immune Ashleaf," "Epicure," "Ninety-fold," "Sharpe's Express," "Snowdrop," "May Queen," "Di Vernon" and "Arran Rose." "Midlothian" was planted again in this series and also in two odd rows at the end of the plots.

All the plots were planted on 8th April, 1925, and the conditions and practices usual in the district for planting potatoes were observed, the seed being well sprouted and twice grown in South Lincolnshire.

Observations on the Plots.

The plants were very slow in appearing through the soil and the whole area was particularly marked by wide gaps in the rows. An examination of the seed in these gaps shewed that the young sprouts had been damaged by *Rhizoctonia solani*. Those plants which appeared above ground were somewhat stunted, and the foliage, particularly on the Bleaching Powder plots, shewed a distinct yellowing, which may have been partly due in this case to the chemical, since a pot experiment laid out in the same way gave the same result. The fungus *Rhizoctonia solani* appeared to be present throughout the whole area and was most probably one of the causes of failure in the crop. Young cysts of *H. schachtii* were first observed on the roots on 23rd May, while large

numbers of worms in various stages of growth were found inside young rootlets.

The best plots at this stage were those which had received the heavy dressing of Potash and those which had received Sodium chloride, while the poorest were the Nitrolim plots. These latter plots would probably have done better if the Nitrolim had been put in the soil some time before planting the potatoes. The Naphthalene plots shewed by far the healthiest plants, although they did not produce so abundant a foliage as on one of the Potash plots, but the haulms remained healthy and green when most of those on other plots had died down. Eelworm cysts, however, seemed to be equally abundant in all cases together with other diseases, particularly *Rhizoctonia solani*.

Observations on the growth of the different varieties in these experiments shewed that "May Queen," "Arran Rose" and "Immune Ashleaf" did best, with "Epicure" and "Sharpe's Express" as a good second. "Di Vernon" started off best of all but soon died down, while "Ninety-fold," "Snowdrop" and "Midlothian Early" did very poorly. Here again none of the varieties shewed any degree of immunity to eelworm.

The potatoes were lifted on August 6th, all those remaining on a 1-inch mesh being weighed and records taken for each plot. The following are the weights obtained:—

SERIES A (4-row Plots).

	Salt.	Sulphur.	Naphthalene.	Lime.	Potash.	Nitrolim.	Bleaching Powder.
	st. lbs.	st. lbs.	st. lbs.	st. lbs.	st. lbs.	st. lbs.	st. lbs.
Original	9 7	6 12	9 5	5 4	6 3	2 11	7 7
Duplicate	7 7	5 11	5 12	5 0	11 4	2 0	7 0
	17 0	12 9	15 3	10 4	17 7	4 11	14 7

Control Plot total, 15st. 7lbs.

SERIES B (3-row Plots).

	Immune Ashleaf.	Epicure.	Ninety-fold.	Sharpes Express.	Snowdrop.	May Queen.	Di Vernon.	Arran Rose.
	st. lbs.	st. lbs.	st. lbs.	st. lbs.	st. lbs.	st. lbs.	st. lbs.	st. lbs.
Original ...	5 7	7 0	1 10	4 10	5 0	14 0	8 7	11 7
Duplicate ...	7 0	10 0	4 7	11 7	2 11	5 12	2 3	4 0
	12 7	17 0	6 3	16 3	7 11	19 12	10 10	15 7

Midlothian Plot, 11st. 7lb.

The great difference between some of the original plots and their duplicates is probably due to the fact that the area shewed a number of bad patches which were not confined to any definite plots. These patches were probably not due to any greater concentration of eelworm cysts at these points since the whole area was well sampled before planting the potatoes, and cysts seemed to be fairly evenly distributed throughout. Observations on other fields infested with eelworm have shown that cysts are often quite as abundant on good patches as on bad ones.

None of the plots could be said to have given a yield anywhere near normal, and from that fact alone it would be unwise to make any recommendations at present. Apart from that, these trials are of practically no value towards elucidating the eelworm problem, as it is impossible to make out a clear case of eelworm damage. Other diseases were abundant, and it seemed as if *Rhizoctonia solani* in particular contributed largely to the failure of the crop.

One might point out, however, that under the existing conditions Potash, Salt and Naphthalene gave slightly better results, while the varieties "May Queen," "Epicure," "Sharpe's Express," "Arran Rose" and possibly "Immune Ashleaf" did better on the whole than "Midlothian Early," which is the variety commonly grown in the District and is very susceptible to eelworm.

Pot Experiments.

A number of potatoes were planted in pots and kept under glass throughout the summer. The effect of the following chemicals was tried:—Lime, Sulphur, Bleaching Powder, Carbide Sludge, Nitrolim, Carbon-bisulphide and Calcium cyanide. A number of control pots were also planted.

In these experiments only the plants grown in the pots containing Carbon bisulphide and the one containing Calcium cyanide shewed any significant difference in the number of cysts found on the roots. In the former case the plant did not make a big growth and shewed some signs of wilting; the number of cysts on the roots, however, was very small as compared with the control pots. The plant in the Calcium cyanide pot made excellent growth and looked particularly healthy throughout; a fair number of cysts were present but much less than in the control pots.

Of the eight control pots which had received only a basal dressing of manure, seven produced good plants, and although the roots were very heavily infected with eelworm, no definite symptoms were observed except for a slight yellowing of the leaves.

Pots were also planted with other possible host plants. No cysts were found on the roots of sugar beet plants, and the same result was obtained by an examination of the roots of this plant growing in fields which are known to be infested with eelworm.

One or two cysts may occasionally be found on the roots of *Chenopodium album*, but the parasite does not seem to attack this plant very readily.

Two cysts were found on Tomato seedlings grown in pots, and one cyst on *Solanum dulcamara*.

Some half-a-dozen pots were planted with Mustard seeds with the view of carrying out various laboratory experiments, but unfortunately no infection was obtained, although this host has been used extensively in Germany for experiments on the eelworm of Sugar Beet.

Mustard seedlings were also grown in a pot together with a potato plant, so that, if Baunacke is correct in his view that some secretion from the roots of the host plant induces the larvæ to hatch out, some might be found on the roots of the Mustard seedlings. None were, however, found, and only very few on the potato roots.

No cysts have so far been found on any other crops commonly grown in South Lincolnshire.

A further report will be made embodying observations on methods of cropping, manuring, etc., in South Lincolnshire, together with any data relating to the control of *H. schachtii*. Some work is also being done in factors influencing the hatching out of the larvæ, and records are also being kept of other eelworm pests in the districts, and material collected for future work.

Journal of Helminthology, Vol. III., *No.* 5, *December*, 1925, *pp.* 193-202.

Tylenchus hordei Schøyen, a Nematode Parasite causing Galls on the Roots of Barley and other *Gramineae*.

By T. Goodey, D.Sc.

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Introduction.

Forty years ago Schøyen (1885) gave an account of a serious disease of barley occurring in the vicinity of Lom in Norway, which was associated with the formation of galls on the roots of the plants. The galls were found to contain eelworms which had without doubt caused their production and the symptoms of disease also. Schøyen named the worm *Tylenchus hordei* n.sp. Similar galls had been found at about the same time by Eriksson (1885) on diseased barley at Pajala in northern Sweden, but he had ascribed their formation to the nematode *Heterodera radicicola* ; Schøyen discussed this and gave reasons for thinking it an erroneous view. Closely similar galls had been found previously on the roots of Sea Lyme Grass, *Elymus arenarius*, by Warming (1877) in Sjaelland, Denmark, and by Trail (1881) at Aberdeen, Scotland. The former had considered that they were caused by *Heterodera radicicola*, whilst the latter thought they were due to a nematode belonging to the genus *Tylenchus*, though he was not positive on this as he only saw female worms.

Since the appearance of Schøyen's original paper in 1885 and a short note by him in 1898 controverting the view expressed by Frank in 1896 that the galls were probably caused by *Heterodera radicicola*, no further work on this parasite seems to have been published. Marcinowski (1909) gave a short note on it with drawings based on Schøyen's original paper, and expressed the view that further observations on the worm were much to be desired.

These considerations lend additional interest to the fact that in the present preliminary paper the parasite is re-described with certain details of its anatomy filled in and illustrated, and the view is upheld that it is a distinct species to which the name *Tylenchus hordei* should apply. It is also shown that the parasite from *Elymus arenarius* can attack barley and the common grass of gardens, *Poa annua*.

Historical.

Schøyen's first paper is written in Norwegian, a fact which, one cannot help thinking, has militated against its being more widely known than has apparently been its lot. It is illustrated by a plate of 14 figures, most of which are good, showing the shape and disposition of the galls on the roots and illustrating quite well the general shape and structure of the adult worms of both sexes, though certain anatomical details are not adequately figured, as will be shown later. It is evident that the worms belong to the genus Tylenchus, and it is consequently difficult to understand how Frank or anyone else, having seen these figures, could have suggested that the parasite was *Heterodera radicicola*.

The writer is greatly indebted to his friends, Dr. J. Davidson, of the Entomological Department, Rothamsted Experimental Station, Harpenden, and Mrs. Davidson, for their most valuable help in translating the paper, a brief outline of which follows.

Schøyen records the occurrence of the disease in Norway, where in the Lom district it was known by the name of " Krok." It had been recognised as far back as 1849, and a gardener named Moe had told him that the galls on the roots contained organisms which he thought were the larvæ of insects.

Dealing with the disease symptoms, he says that the parasites attack young plants which turn a pale yellow colour; those plants heavily attacked die without making shoots, and the others become weaker and deformed in growth. The roots of diseased plants bear nodules irregular in shape which, on being opened, reveal whitish worms visible to the naked eye. Adults and eggs as well as larvæ in all stages of development are to be found together, and it is clear that several generations are passed in a year.

Schøyen dealt with the differences between his worm and *Heterodera radicicola*, and was fully alive to the fact that he was dealing with a hitherto undescribed species of Tylenchus. He asserts that Warming's conclusion that the nodules found by him on *Elymus arenarius* were due to *H. radicicola* was based on the opinion of a Dr. Müller, who did not examine the contents of the galls but merely judged by their external characters. Examination of the inhabitants of such galls is an essential, and it is erroneous to assume that all root galls are due to *H. radicicola*. He also determined that when galls are dried the worms can withstand desiccation and revive on re-moistening, a fact which Trail also noted.

His account of the morphology of the adult worms is fairly complete; he gives measurements of most of the important regions of the body in both sexes and describes their respective genital systems, the eggs and the larvæ. There are two parts of the adults which are insufficiently described and figured. These are (1) the œsophagus, and (2) the spicules.

(1) After dealing with the mouth stylet and the first œsophageal bulb he says that the œsophageal lumen extends backwards as a fine line and becomes lost in the granular material of the body; his drawing shows the region without any connection between œsophagus and intestine. The adequate definition of this second region of the œsophagus is important, as the genus *Tylenchus* differs from the other plant parasitic nematode genera, *Aphelenchus* and *Heterodera*, in possessing a second œsophageal swelling, spatulate in shape and finely granular in structure.

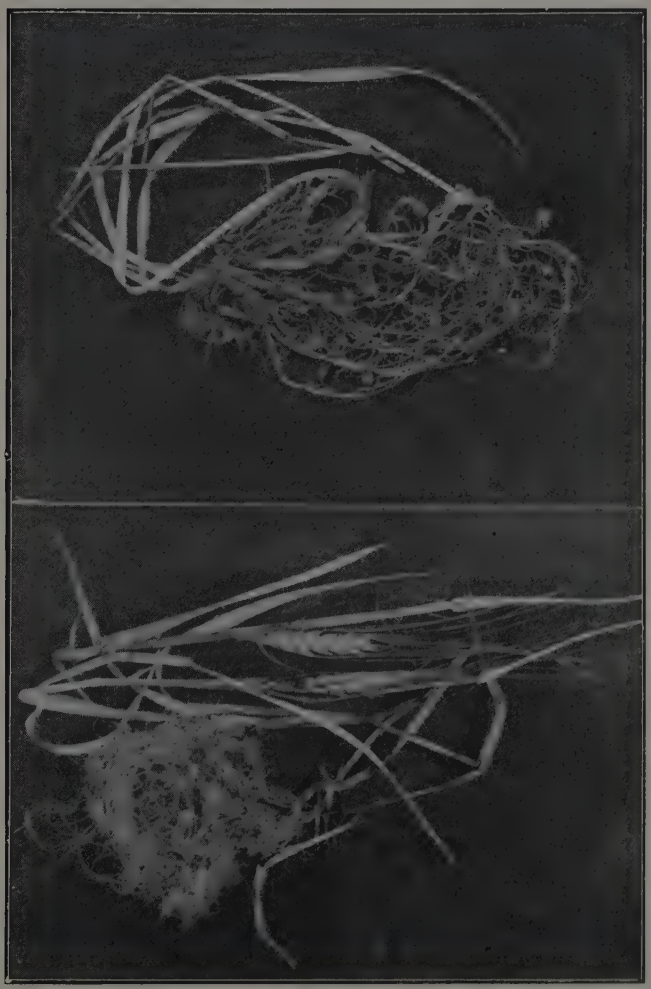
(2) The male tail is figured and shows the caudal alæ characteristic of the genus *Tylenchus*, but the spicules are not accurately drawn and no accessory piece is shown. This is not surprising, as these structures are only to be made out under high magnification.

Dealing with the distribution of the disease he expressed the view that the parasite had probably spread from *Elymus* to barley, for although he did not look for the characteristic galls on *Elymus* in the Lom area, as he was not at the time aware of the records of Warming and Trail, he states that the diseased barley was growing in proximity to masses of this grass which occurs in large tracts in marshy borders close to the outlet of the River Boevra. Here the diseased barley is found. The

gardener Moe told him that he had noticed that the *Elymus* in that region was stunted and crippled in appearance and had previously been considered by a Professor Fries to be a special alpine variety. Schøyen suggests that in the case of Eriksson's finding of nodules on the roots of diseased barley at Pajala the parasite had spread from some wild grass, probably *Elymus*, as this is known to occur even farther north than that place. He says that coarse sandy loam on a cold clay sub-soil seems to be the type of soil favourable to the parasite and that it is probably spread by irrigation. "Krok" in the Lom district is quite a common disease of barley, just as wireworm attack may be in other parts of the country, and he notes that Eriksson records the opinion of a farmer in the Pajala region that it had been responsible for great losses there also. Where barley had been grown year after year the disease had become very marked. Finally Schøyen discussed measures which might be adopted to check the further spread of the disease, and concluded that some form of crop rotation with barley omitted for as long as possible should be tried. He thought that the use of a catch crop such as had been recommended by Kühn for checking the disease of rye caused by *Tylenchus dipsaci* would be useless.

The substance of Schøyen's second note on the parasite has already been mentioned in the introduction to the present paper, where Trail's findings are also briefly touched upon. The latter gave measurements of eggs, immature larvæ and a young adult female, and in addition described the differences between a normal rootlet and a gall as revealed by cross sections.

The original papers of Warming and Eriksson have not been seen by the writer, but as they are dealt with fully by Schøyen it is felt that nothing important has been overlooked. Markinowski (1909) refers to a note by Henning (1898), an abstract of which appeared in 1899 in the Zeitschrift für Pflanzenkrankheiten. This merely mentions what was already known of the occurrence of *Tylenchus hordei* on barley in Sweden, Norway and north Finland, on *Elymus* in Norway, Denmark and Scotland. It concludes by saying that it attacks *Poa pratensis* and probably oats in Sweden, though no one is mentioned as authority for these statements.



Root Galls of *Tylenchus hordei* on
(*a*) *Elymus arenarius*. (*b*) Barley

(To face p. 196)

The material which has served for the present work consisted of galls on the roots of *Elymus arenarius*. The plants were collected in the vicinity of Aberdeen in the summer of 1924 by Mr. W. E. H. Hodson, of Seale-Hayne Agricultural College, Newton Abbot, Devon, who submitted a few of the fixed galls from the roots for the writer's examination, and at a later date very kindly handed over to him a number of infected living specimens of *Elymus arenarius*. The best thanks of the writer are due to Mr. Hodson for his generosity in this matter.

A photograph of one of these parasitised plants is shown in the plate accompanying this paper. It can be seen that the galls are of variable size and that many of them are quite large. When one of them is opened under water the worms are found inside. There may be 3 or 4 up to 12 or 15 fully or almost fully grown worms in a single gall besides large numbers of eggs and larvæ in various stages of development.

Morphology.

Mature adults are easily visible to the naked eye and the males are more active than the females. The latter are longer and broader than the males and may attain a length of more than 3 mm. Schøyen gave measurements as follows:—females, 1·57–2·72 mm. long by 0·07–0·12 mm. wide; males, 1·4–2·02 mm. long by 0·04–0·07 mm. wide, adding that gravid females are very variable in dimensions. Of the worms examined alive by the writer many were much larger than these figures indicate. Three large females measured at random gave the following figures:—2·95, 3·15 and 3·2 mm. in length, with a maximum breadth of approximately 0·12 mm. Three fully grown males measured 2·6, 2·72 and 2·77 mm. in length and each had an approximate breadth of 0·1 mm.

The shape and gross anatomy of a typical adult male and female are shown in Figs. 1 and 2. It can be seen that in both sexes the body tapers towards the head and the tail, and that the latter is provided with a narrow terminal portion which ends in a sharp point, the tapering to which is all on the dorsal side of the body. The cuticle is transversely striated and the alimentary canal has a common plan in both sexes. The anterior end when examined under fairly high

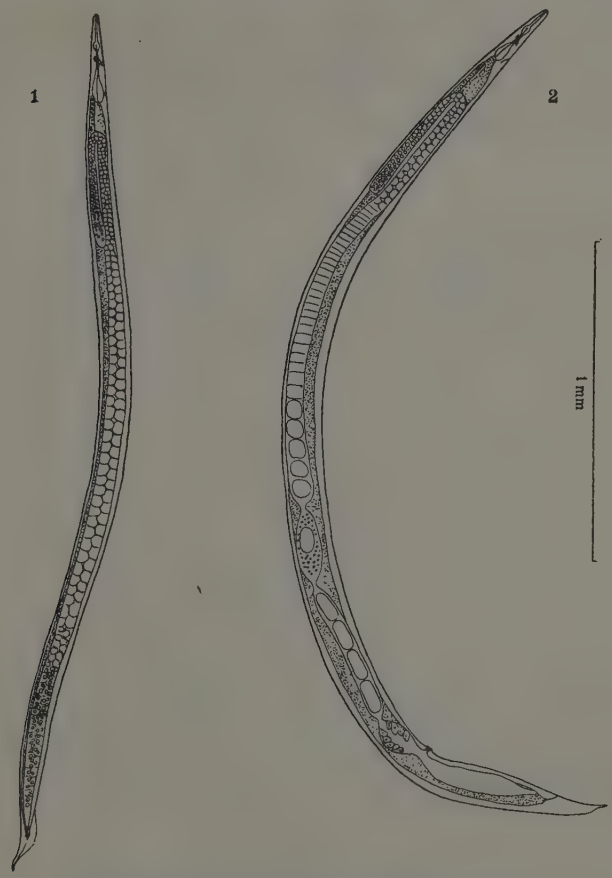
magnification is seen to be rounded and the cuticle is raised up into a boss-like structure composed of 6 stout ridges or lips fused together. In the centre of this is the mouth aperture within which, on careful focussing, the extremely fine point of the mouth stylet can be discerned. The stem of this extends a short distance backwards, gradually increasing in diameter until at its posterior end it expands into a trilobed swelling.

It is from 0·01–0·015 mm. in length and is followed by the œsophagus, in the middle of which is the narrow lumen visible as a highly refractive line. Where the lumen joins the stylet a short blind diverticulum is given off laterally. At about 0·08–0·1 mm. from the anterior end of the body is the first œsophageal bulb which is a well marked swelling with muscular walls, the inner lining of which is raised into three thickened ridges at or just in advance of the centre of the bulb. Following the bulb, the œsophagus narrows down considerably and after about 0·08 mm. swells out into the second œsophageal bulb, which is much larger than the first bulb and is spatulate in shape. The lumen runs through it as a narrow line and then opens into the intestine. The substance of the swelling is finely granular in appearance, and on each side of the lumen may be seen a large nucleus with a large karysome. This second œsophageal bulb is probably glandular and may function as the œsophageal or salivary glands.

The intestine and its walls are generally densely packed with coarse food granules which tend to obscure the rest of the organs. There is a narrow rectum leading to the anus which in both sexes is found at from 0·11 mm. to 0·14 mm. from the tip of the tail. The nerve ring lies across the œsophagus a short distance posterior to the first œsophageal bulb, and the excretory pore is found at about 0·22 mm. from the anterior end at the level of the second œsophageal swelling.

The males have narrow caudal alæ simulating a bursa and possess a pair of spicules and an accessory piece. The alæ are transparent expansions of the cuticle which arise latero-ventrally at about 0·08 mm. anterior to the anus, increase gradually in width until they reach their widest extent at about the level of the anus and then gradually diminish again until they join the body wall at about 0·09 mm. behind the anus. There are no rays supporting these alæ. The anus or rather cloacal aperture is situated on a slight prominence.

The spicules have their points directed towards the cloacal opening



Tylenchus hordei. Fig. 1, male. Fig. 2, female.

close to which also lies the flattened and pointed accessory piece. Each spicule is curved and is placed at an angle to the longitudinal axis of the worm, so that in lateral view one does not obtain the whole of it in focus at one and the same time. It may be said to consist of two parts, a proximal " handle " which gradually increases in diameter from the sharp point, and a distal expanded and somewhat flattened

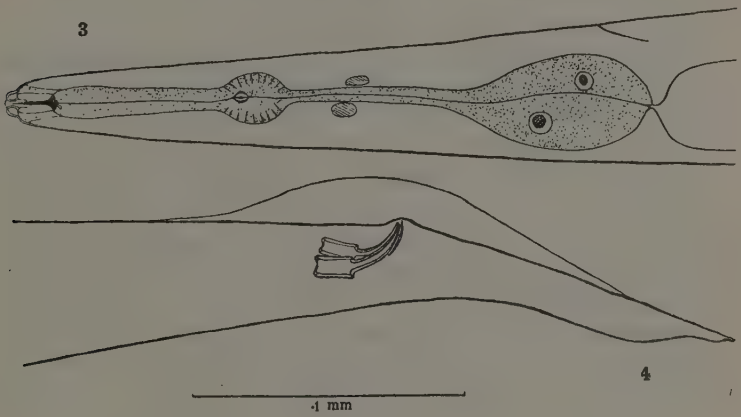
"blade." The two parts divide the spicule in the proportion roughly of 2 handle to 1 blade. The total length is rather less than 0·04 mm. and the accessory piece measures about 0·015 mm. The gonad is single and calls for no special description. It extends longitudinally in the body as a cord of cells, gradually becoming narrower, and folds on itself anteriorly just as the ovary does.

The vulva is a transverse slit situated at about 0·5–0·65 mm. from the tip of the tail; its lips are frequently rather prominent. It opens into the uterus, which consists of a post-vulvar blind sac reaching in many cases almost to the level of the anus and a much shorter pre-vulvar portion which is the uterus proper. The walls of this are furnished with large cells, probably muscular in function, which project into the lumen of the uterus. They are well figured and described by Schøyen. Proceeding anteriorly the uterus leads, after a slight constriction, into the oviduct which may contain from 1 to 4 or 5 eggs, and according to the number of eggs present in it its walls are distended or collapsed. Following another slight constriction of the gonadial tube comes an expanded portion, the receptaculum seminis, in which the writer was able to distinguish small rounded bodies, probably spermatozoa. Anterior to this is the ovary proper, which is composed of a single rachis of cells which gradually decrease in size as they approach the head end of the body. The cord of cells bends upon itself anteriorly close to the junction of the intestine and the œsophagus, and frequently forms a double U-shaped curve here with the narrow end lying close up by the œsophagus. The eggs lying in the uterus are cylindrical in shape with rounded ends and measure from 0·096–0·11 mm. in length by 0·04–0·041 mm. in width.

Experimental.

As the material studied was from galls on the roots of *Elymus arenarius*, while Schøyen had dealt with worms from barley root galls, it seemed desirable to determine whether the worms from Elymus could set up galls on the roots of barley. Only a very small quantity of living gall material was available at the time, and the experiment was confined to one or two small pots which were kept sunk in clean ashes to prevent excessive evaporation and afford suitable drainage. On May 3rd,

1925, three barley seeds were sown in a compost of loam, sand and leaf-mould in a three-inch pot. At the time of sowing a small quantity of sand was added containing active larvæ of *Tylenchus hordei* obtained from a decayed root-gall on *E. arenarius*. Two barley seedlings subsequently made their appearance and gradually grew until by the beginning of September there were two plants about a foot high each bearing an ear of barley. The plants were turned out of their pots



Tylenchus hordei. Fig. 3, anterior end. Fig. 4, male tail.

temporarily at the beginning of July, when the roots were seen to bear one or two nodules. When finally the plants were brought to the laboratory and the soil was washed away from the roots, 12 or 14 well formed galls were found. One of these was opened with needles under water and several adult specimens of *T. hordei*, together with numerous eggs and developing larvæ, were revealed.

The plants never looked healthy during the growing period, but as the intention of the experiment was merely to test the possibility of infecting barley from Elymus, no control pot was set up for comparison. The positive result obtained shows that the parasite from Elymus can set up galls on barley and is an experimental proof supporting Schøyen's suggestion that the disease of barley in Norway had probably spread from *E. arenarius* to the cultivated plants.

At the same time as the barley seeds were sown another three inch pot had planted in it a single plant of *Elymus glaucus*, an ornamental variety of *Elymus arenarius* which happened to be available. The soil was similarly infected with larvæ in a small quantity of sand containing the remains of a decayed root gall from *E. arenarius*. At the beginning of September when this plant had grown considerably its roots were examined and found to be carrying a number of galls, one of which, when opened, shewed adult and larval specimens of *T. hordei*. Growing in the same pot were two self-sown plants of the common grass, *Poa annua*. The roots of these were washed and carefully examined, with the result that galls were found on them, and in one of the galls which was opened a number of *T. hordei* were found, thus showing that this species of grass is also susceptible to attack by the parasite. Trail (l.c.) mentions that "root galls formed by these creatures have also been found on *Poa annua*," and in addition he mentions their occurrence on *Triticum repens*, on wheat, on barley and on oats, though he says he was not aware that they had been met with on these plants in Scotland. Unfortunately he does not cite the discoverer of the galls on wheat, oats, *Triticum repens* and *Poa annua*. In the same way Henning, as already mentioned, does not give a reference to the recorder of the galls on *Poa pratensis*.

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Journal of Helminthology, Vol. III., *No.* 5, *December, 1925, pp* 203-208.

Remarks on the Anatomical Structure and Systematic Position of the Stork's Lung-Filaria.

By George Witenberg

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The following note is based on a sample of Filariæ collected by Dr. W. Stefanski (University of Warsaw) from the trachea of a Black Stork shot in the neighbourhood of Warsaw and generously placed by him at my disposal.

The bottle obtained from Dr. Stefanski contained 18 entire specimens, 13 females and 5 males.

The determination of the material showed that the Filariæ belong to a species already described by several authors as parasites of the aerial sacs, trachea and bronchi of the White and Black Storks (*Ciconia alba* and *C. nigra*) under the following names :—*Filaria ciconiæ* Schrank 1788, *Filaria ciconiæ nigræ* Rudolphi 1819, *Filaria labiata* Creplin 1825, *Dicheilonema labiatum* Diesing 1860, *Contortospiculum ciconiæ* (Gmelin 1791.)

We must emphasise that Skriabin (1915), who had established the correct specific name of this species, had wrongly designated its author. The first author to name this species was Schrank (1788), who described it under the name *Filaria ciconiæ*. On this account the present name of this worm must be *Contortospiculum ciconiæ* (Schrank 1788), not "Gmelin 1791," as Skriabin noted.

Nevertheless we are completely in agreement with Skriabin (1915) as well as with Hall (1916, pp. 221-222) in ignoring the generic name *Dicheilonema* proposed by Diesing, 1860. The diagnosis of this genus is so uncertain, and all ten species simultaneously noted are so different, that it would be most expedient to consider the genus *Dicheilonema* Diesing 1860 as *Nomen nudum.*

The detailed examination of this species is very interesting for the reason that, in spite of a fairly large literature and even some detailed

anatomical descriptions given by certain authors (*e.g.*, Nathusius, 1837), its most important characters are not sufficiently well known.

Skriabin (1915), who placed this species in his new genus *Contortospiculum*, based his opinion on the inadequate descriptions given by the previous authors, being convinced that its morphology is correlated with the construction of other organs, especially with those of the anterior end of the body, which shows the chief features of the genus. From the latter characters Skriabin takes as the most remarkable the cuticular formation surrounding the mouth-opening in the shape of the " shoulder-knots," which he examined in *Contortospiculum horrida* (Diesing 1851) and the presence of which he supposed in *C. ciconiæ* (Schrank 1788).

These formations Skriabin considers as homologous to the similar structures in the representatives of the genus *Serratospiculum* Skriabin 1915, and to the trident of the genus *Diplotriæna* Raillet & Henry 1909 ; he therefore unites these three genera in the subfamily Diplotriæninæ (Skriabin 1915*).

Our examination confirmed entirely Skriabin's surmise concerning the " shoulder-knots " as well as the other anatomical characters which agree with the generic diagnosis of *Contortospiculum* Skriabin 1915, in spite of some differences in size of spicules and in the number of the genital papillæ.

The most detailed description of *Contortospiculum ciconiæ* (Schrank 1788) is given by Nathusius (l.c.), the best figure by Schneider (1866). As, however, both show some want of precision, especially concerning the details which are important for classification, we propose to redescribe this species.

Body cord-like, cylindrical, not uniformly thick, but slightly narrowed to the caudal extremity. Cuticle delicately striated transversely. The structure of the mouth-apparatus in both male and female is identical. Even under low magnification two massive teeth (labia *auctorum*) are

* In his recent paper published in Rus. Journ. of Trop. Med., 1923, Skriabin established a fourth genus of this Subfam. Diplotriæninæ, which genus also is characterised by " epaulet-like formations."

distinctly seen (Figs. 1 and 2); they project on the sides of the small oval oral aperture and have the shape of flat truncated chitinous cones. These teeth, when observed from above, are 0·014 mm. thick and 0·035 mm. broad; the distance between them is 0·08 mm.

Lateral to the base of each tooth one sees (but only in well cleared preparations) two characteristic figures which Skriabin very fortunately named " les formations en épaulettes." These formations have the outlines in the shape of two oval plates 0·013 mm. broad, each having laterally three little round plates of irregular shape (see Fig. 3). On each of these little plates there is a small papilla, and between them are situated two large almost round depressions; these are undeniably organs of sense, for on each side of the mouth-opening we were able to observe five papillæ and other sense organs. We emphasise this peculiarity because in spite of very careful examination we were not able to observe the additional papillæ on the median little plate, which Skriabin notes in the diagnosis of the genus *Contortospiculum*.

For the closer examination of the anatomical structure of the epaulet-like formations longitudinal serial sections were made. They showed that these formations are only thickenings of the cuticle surrounding the mouth opening, and are not analogous to the chitinous trident originating in the parenchyma in the representatives of the genus *Diplotriæna* Raillet & Henry 1909.

The œsophagus consists of two portions: the anterior, thin and short, and the posterior, thick and long.

Male.

The length of the body 7·5–10·2 mm., breadth at the anterior end 0·34 mm., at the posterior end (in front of the alæ) 0·28 mm. The parts of the œsophagus measure 0·50 × 0·12 mm., and 0·63 × 0·62 mm.

The posterior extremity of the body is provided with two alæ 0·62 mm. in length and 6 pairs of long finger-shaped papillæ curved inwardly and 8 small ones. 5 pairs of these longer finger-like papillæ (4 pairs pre-anal and 1 pair post-anal) are situated at the sides; the 6th pair, which is smaller, immediately before the cloacal opening. One of the eight small papillæ is placed cephalad to the cloacal opening, the remaining 7 are symmetrically arranged at the tip of the tail (Fig. 4).

The cloacal opening is placed 0·16–0·18 mm. from the posterior extremity; it is an oval slit, 0·03 mm. × 0·05 mm., bounded by two lips, the anterior narrow and transversely striated, the posterior shaped like a prominent oval papilla.

Spicules are different in size (Fig. 5), the larger one is 1·25 mm., the smaller one 0·35 mm. in length. They do not resemble in size the spicules of *Contortospiculum horridum* (Diesing). They are less curved, and although their alæ-like borders are bent in the form of a gutter, the latter are not as broad and denticulated as in that species.

Female.

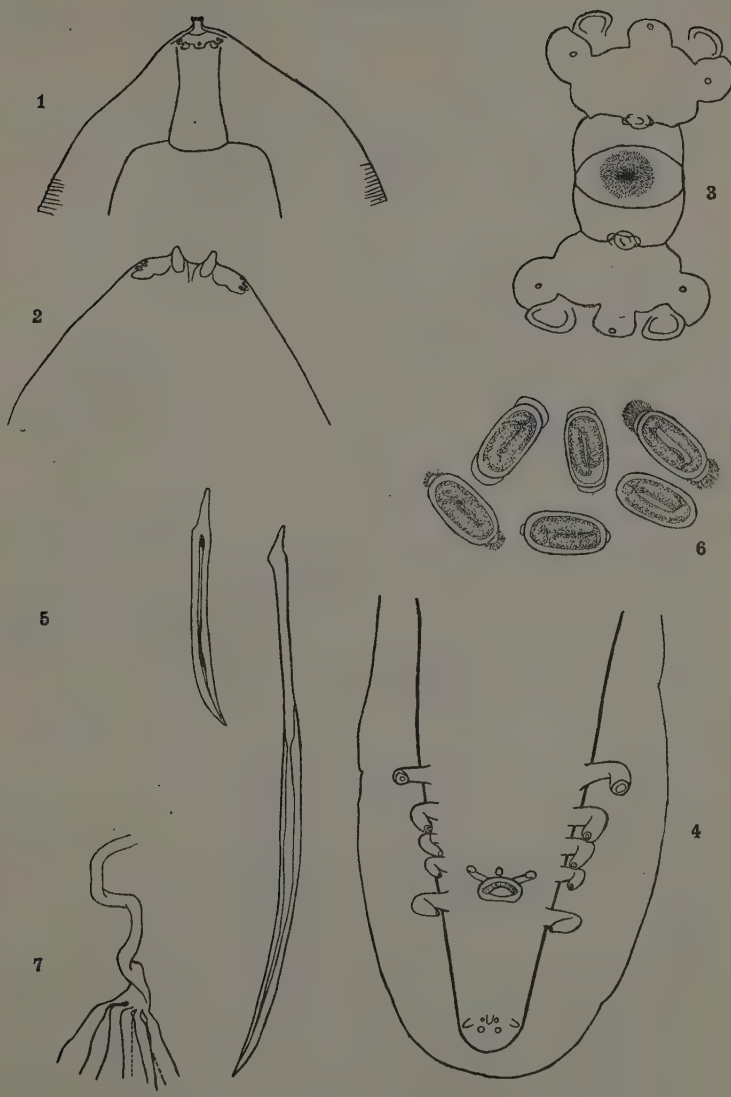
Length of body 560–680 mm., the thickness at the anterior extremity 1·7 mm., at the posterior end 0·9 mm.

The œsophagus is divided into two portions: the anterior is 0·47 mm. long and 0·26 mm. broad, the posterior is 17·0 mm. long and 1·0 mm. broad. The anus is situated at the posterior end of the body, which is rounded in shape and is not provided with any external organs or appendages.

The vulva is placed 0·3 mm. from the mouth-opening. The vagina measures 16·0 mm. in length and 0·4 mm. in breadth, and is formed by the fusion of 5 (not 4 as Schneider notes) uteri provided with short sphincters and directed caudad (Fig. 6).

In the bottle containing the above-mentioned worms a sediment was found, consisting of eggs liberated from the broken specimens. The ripe eggs have an oval shape and contain a coiled embryo. Various eggs containing an equally developed embryo are, however, enclosed in three kinds of shells: 1, smooth; 2, provided with "bolsters"; or 3, with tufts of bristles at both ends (Fig. 7). These three kinds of shells characterise three stages in the development of the eggs, and those which are provided with bristles may be considered as the most developed. Apart from the appendages, all the eggs have an equal size, 0·052 mm. × 0·024 mm.

Schneider (l.c.), describing *Contortospiculum ciconiæ* (Schrank) states that this species does not differ from the second species of this genus



EXPLANATION OF FIGURES.

Contortospiculum ciconiæ (Schrank 1788).

1.—Anterior extremity, lateral view. 2.—Ventral view.
3.—Epaulet-like formations, as viewed from above.
4.—Posterior extremity of male. 5.—Spicules. 6.—Eggs. 7.—Vagina and uteri.

(*C. horrida* Diesing) except in the number of its uteri, the former having four and the latter two.

We now possess the extensive description of *C. horrida* (Diesing) given by Skriabin and the above concerning *C. ciconiæ* (Schrank). On comparing them we may bring out the differences between these two species which have an importance in classification.

	C. ciconiæ.	*C. horrida.*
The number of organs of sense on the anterior extremity of the body	10	14
Denticulation of the larger spicule ...	absent	present
The shape of the smaller spicule ...	straight	curved
The sizes of the spicules	1·125 mm. and 0·353 mm.	0·9 mm. and 0·34 m.m.
The number of the uteri	5	2
Adanal papillæ in male	present	absent

I take this opportunity of expressing my deep gratitude to Dr. W. Stefanski who generously placed at my disposal the material on which the present study is based, as well as to the staff of the Institute of Hygiene, especially to Dr. L. Anigstein, for the privilege of carrying out this work in their laboratories.

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A Review of the Members of the Genus *Streptopharagus* Blanc, 1912.

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Since Blanc created the genus Streptopharagus in 1912 for the reception of a nematode parasite from the stomach of *Macacus cynomolgus* (India ?) which he named *S. armatus*, three papers have appeared from different sources, each of which deals with what its author took to be examples of *S. armatus* Blanc. The first of these papers is by Vevers (1922), in which he records and figures some specimens obtained from *Macacus nemestrinus* (India). The second is by Baylis (1923), describing and figuring specimens obtained from *Papio langheldi* (Tanganyika Territory). The third is by Mönnig (1924), in which specimens obtained from *Papio porcarius* and *Cercopithecus pygerythrus* (Transvaal) are described and figured.

A comparison of the descriptions and figures of these three authors is sufficient to show that each was dealing with a different species of parasite, and as each considered he was dealing with specimens of the genotype, it becomes sufficiently clear that a re-study of the members of this genus is necessary in order that any ensuing confusion may be avoided.

During the present writer's association with the collection and identification of the helminth parasites from animals dying in the gardens of the Zoological Society of London, members of the genus Streptopharagus have been collected from *Macacus nemestrinus* (once), *Cercopithecus patas* (twice), and *Papio hamadryas* (five times). In addition the writer has been able to examine examples of Streptopharagus collected from a Gerbil and deposited in the Helminthological collection of the London School of Hygiene and Tropical Medicine.

From an examination of all this material the writer has come to the conclusion that only the specimens described by Vevers represent the

true *S. armatus* Blanc. Those described by Mönnig belong to the species *S. pigmentatus* (Linstow), and those described by Baylis must be regarded as a new species. In addition the specimens collected from *Cercopithecus patas* are tentatively referred to a new species.

STREPTOPHARAGUS ARMATUS Blanc 1912.

Syn. *Streptopharagus armatus* Blanc of Vevers 1922.

Not *Streptopharagus armatus* Blanc of Baylis 1923, from *Papio langheldi*.

Not *Streptopharagus armatus* Blanc of Mönnig 1924, from *Papio porcarius* and *Cercopithecus pygerythrus*.

The writer has been able to re-examine the material on which Vevers based his description and figures. This material agrees in all essentials with the data given by Blanc, except that the worms are slightly larger, the males reaching a length of 34 mm. and the females 61 mm.

The mouth is guarded by two lateral trilobed lips each bearing a dorso-lateral and a ventro-lateral papilla. The six internal teeth are simple, as are also the small dorsal and ventral teeth. The pharynx is given by Blanc as 0·4 mm. long ; in the writer's material it is 0·39 mm. long in the male and 0·6 mm. long in the female. The distance from the anterior end to the end of the œsophagus is 7·2 mm. in the male and 9·5 mm. in the female ; Blanc gives this distance as 8 mm., but it is not clear whether this refers only to the male or only to the female, or to both sexes. The anterior end is swollen and the cervical papillæ are asymetrically placed, that of the right being more posterior than that of the left side ; in the male they are 0·61 and 0·3 mm. and in the female 0·76 and 0·38 mm. from the anterior end respectively. The excretory pore is situated just anterior of the level of the junction of the muscular and glandular regions of the œsophagus.

The male genitalia agree very closely with Blanc's data except that there is a pair of sessile papillæ just behind the ano-genital aperture and a group of ten small papillæ on the ventral surface near the tip of the tail (Fig. 1). These papillæ were probably overlooked, as Vevers also did not notice them. As stated by Vevers, a gubernaculum is present measuring 0·066 mm. in length. The spicules are very unequal in length. Blanc gives the length of the right and left spicules as 0·5

and 4 mm. respectively ; in the writer's material the length of the right spicule is 0·5–0·54 mm. and that of the left 4–4·28 mm. There can thus be no doubt that Blanc measured an entire left spicule and not a broken one, as suggested by Baylis. Claw-like cuticular structures on the ventral surface of the tail of the male are absent.

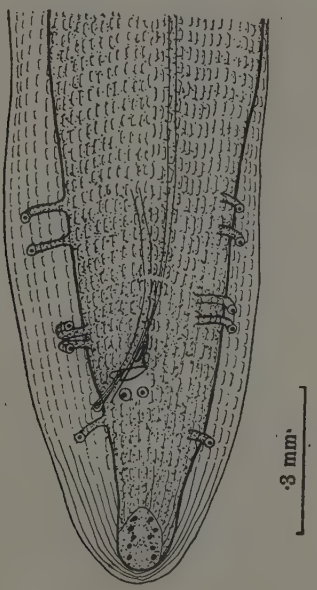

Fig. 1.—*Streptopharagus armatus.*
Tail of male, ventral view.

The female genitalia have their external orifice 12·18 mm. from the anterior end, *i.e.*, the position of the vulva divides the body into the ratio of 1 : 4 ; this is also the relation derived from Blanc's data. The vagina is about 9 mm. long and passes backward to join the two uteri. The eggs are oval, smooth shelled and embryonated *in utero* ; they are from 0·032–0·035 mm. long by 0·019–0·022 mm. broad.

Hosts. *Macacus cynomolgus,* India ? (Blanc).
Macacus nemestrinus, India (Vevers).

STREPTOPHARAGUS PIGMENTATUS (v. Linstow, 1897), Raill., & Henry, 1918.

Syn. *Spiroptera pigmentata* v. Linstow, 1897.
Streptopharagus armatus Blanc of Mönnig, 1924, from *Papio porcarius* and *Cercopithecus pygerythrus*.

This species has been well described and figured by Mönnig under the name of *S. armatus* Blanc. Mönnig's observations agree with those of the writer, except that the latter is unable to see the two groups of three papillæ on each of the lips; in all the specimens examined by the writer there were only two large papillæ on each lip, one dorso-lateral and one ventro-lateral in position, and in addition there appears to be a rudimentary papilla on the outer side of each lip papilla. The eggs also are slightly larger than those seen by v. Linstow and Mönnig, being 0·04–0·042 mm. long by 0·03–0·028 mm. broad.

The chief diagnostic features of this species are that the males vary in length from 28–52 mm. and the females from 60–63 mm. The teeth and the pharynx are similar to those found in *S. armatus*, and the head has a pronounced cuticular inflation. The left spicule is 6·5–6·7 mm. long, the right 0·72–0·75 mm. long, and the gubernaculum from 0·07–0·078 mm. long. The vulva divides the body into the ratio of about 1 : 3·5 and the eggs appear to vary in size from 0·038–0·042 mm. in length by 0·02–0·03 mm. in breadth.

Hosts. *Cercopithecus albigularis*, Africa ? (Linstow).
Macacus sp., Belgian Congo (Raill. & Henry).
Cercopithecus pygerythrus, Transvaal (Mönnig).
Papio porcarius, Transvaal (Mönnig).
Papio hamadryas, Abyssinia (Ortlepp).

STREPTOPHARAGUS INTERMEDIUS sp. nov.

The specimens of this species consist of two females and four males collected on two occasions from *Cercopithecus patas*; in the one case only females and in the other only males were obtained. The males vary in length from 42–45 mm., and the two females are respectively 40 and 46 mm. long; the males are about 1 mm. thick and the females about 1·3 mm.

The head shows only a very slight inflation, and can thus be easily distinguished from that of *S. armatus* and *S. pigmentatus*.

There is no cervical ala, and the cervical papillæ are very asymetrically placed; they are 0·7–0·8 mm. for the right and 0·3–0·32 mm. for the left in the male, and 0·7–0·25 mm. for the right and left respectively in the females from the anterior end. The excretory pore occupies the same relative position as in the two preceding species. In other characters this species is similar to these two species except that the left spicule is slightly larger than that found in *S. armatus* and only about $\frac{2}{3}$ the length of that of *S. pigmentatus*. The right spicule is 0·6–0·63 mm. long and the left 4·6–4·9 mm. long. Also the vulva is more posterior in position, dividing the body into the ratio of 1 : 2.

The writer has tentatively referred these specimens to a new species because of the constancy of the characters in the specimens at his disposal. It shows a very close relationship to both *S. armatus* and *S. pigmentatus*, occupying an intermediate position between these two species. It is, however, quite possible that with access to more material it may be found that this species is the same as either *S. armatus* or *S. pigmentatus*.

Streptopharagus numidicus Seurat, 1917.

Seurat's (1917) original description of this species is very brief and consists of a few measurements only. Later (1918) he fully re-described it with figures of the head and teeth and of the tail of the male. The female specimen he had for observation was immature, and the male was probably a young adult.

This species is characterised by the tripartite nature of its six buccal teeth and of the dorsal and ventral teeth, the very posterior position of the vulva dividing the body into the ratio of 1 : 1·2, and the left spicule is only about 2 mm. long (1·9 mm.).

Host. Fennec Fox (*Vulpes cerdo*) North Africa? (Seurat).

The writer is also tentatively referring to the above species two poorly preserved specimens from a Gerbil—*Gerbillus pygarus*, Egypt. The male is 13 mm. long and the female 14 mm., and it is probable that both represent young adult stages. The male tail, which is much macerated, appears to be similar to that figured by Seurat; the left spicule is 2·2 mm. and the right 0·48 mm. long. Unfortunately the body contents are decomposed in both specimens, so that it is not possible

to make out the structure of the internal organs ; neither is it possible to locate the position of the vulva.

Streptopharagus sudanensis Baylis 1923.

Baylis based his description and figures of this species on females obtained from *Gerbillus gerbillus*. The species appears to be nearly related to *S. numidicus* Seurat, from which species it differs by its larger size (41 mm.) and the more anterior position of the vulva, its position dividing the body into the ratio of 1 : 4. It must, however, be remembered that Seurat's material was young, and the position of the vulva in the 4th stage female may not necessarily represent its final position in the adult. It is thus possible that with access to more material it may be found that *S. sudanensis* is a synonym of *S. numidicus*, and that the Gerbil is the normal host, the Fennec Fox being only an accidental one.

Host. *Gerbillus gerbillus*, North Africa ? (Baylis).

Streptopharagus baylisi n. sp.

Syn. *Streptopharagus armatus*, Blanc of Baylis, 1923, from *Papio langheldi*.

The writer has obtained this species on three occasions from *Papio hamadryas*, once in association with *Streptopharagus pigmentatus*.

The writer's findings agree in essentials with those of Baylis except that the writer's specimens are smaller, the males not exceeding 25 mm. and the females 39 mm. in length. A conspicuous ala is present on the left side of the anterior quarter of the body. The left spicule of the male was found to vary from about 10–11·5 mm. ; the tip of the right spicule is hooked, and there are two sessile papillæ immediately behind the cloacal aperture in the male (Fig. 2). In 36 and 39 mm. long females the vulva was situated 11·76 and 13 mm. from the anterior end respectively, and the tail was 0·46 mm. long.

This species is very similar to the genotype, from which it differs in the very great length of the left spicule (over 10 mm.), and in the presence in the male " on the left side of the tail, towards the mid-ventral line, and extending across it in front of the cloacal aperture " of " a series of prominent, claw-like structures, having their tips hooked and appearing

as if partly chitinized " ; also the vulva is much further back, its position dividing the body roughly into the ratio of 1 : 1·4 to 1 : 2.

Hosts. *Papio langheldi*, Tanganyika Territory (Baylis).
Papio hamadryas, Abyssinia.

The writer has much pleasure in naming this species in honour of Dr. H. A. Baylis.

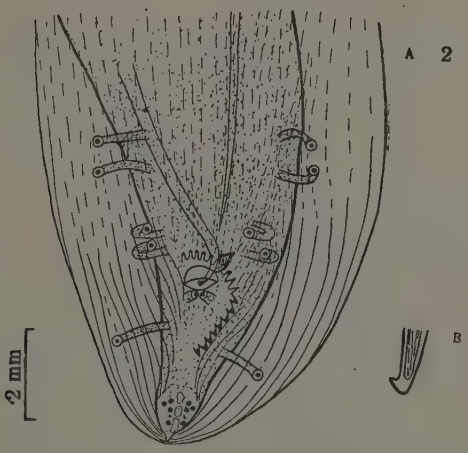

Fig. 2.—*Streptopharagus baylisi* n. sp.
(*a*) Tail of male, ventral view.
(*b*) Tip of right spicule.

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Index to Vol. III.

Index of Authors.

CORRIGENDA FOR VOL. III.

Page 41, legend to figure, for *cestus* read *cæstus*.
Page 49, legend to figure, for s.p. read sp.
Page 84, line 4 from bottom, for *acanthura* read *acanthinurus*.
Page 89, line 8 from top, for acanthurus read acanthinurus.
Page 90, line 4 from top, for *acanthura* read *acanthinurus*.
Page 123, line 9 from top, for *uromasticolla* read *uromasticola*.
Page 124, line 12 from bottom, for *Uromastrix* read *Uromastix*.
Page 150, under Seurat 1912, for *acanthurus* read *acanthinurus*.

VOL. II. (1924).

Page 84, line 9 from top, for woman read worm.

NEW NAMES IN VOLUME III.

New Family.

New Genera.

New Species.